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

Current Status of the Technical Management of Underground AMD

Study Report No. 5.1

P RSA 000/00/16512/1

EDITION 1

May 2013

water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF WATER AFFAIRS

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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

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 on the Witwatersrand, has decreased since the 1990s, and underground mining on 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 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**.

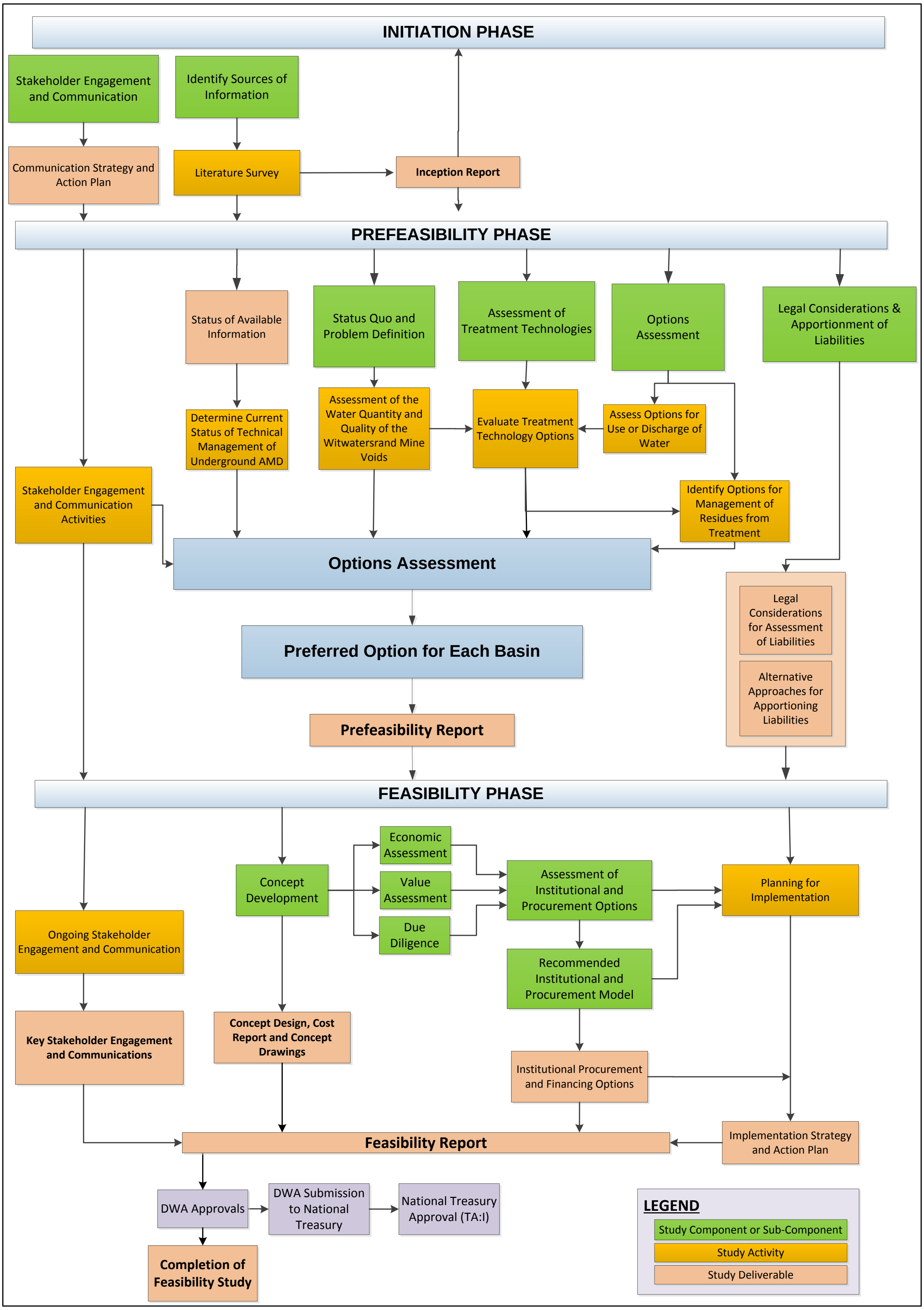

Figure 1: Study phases and components

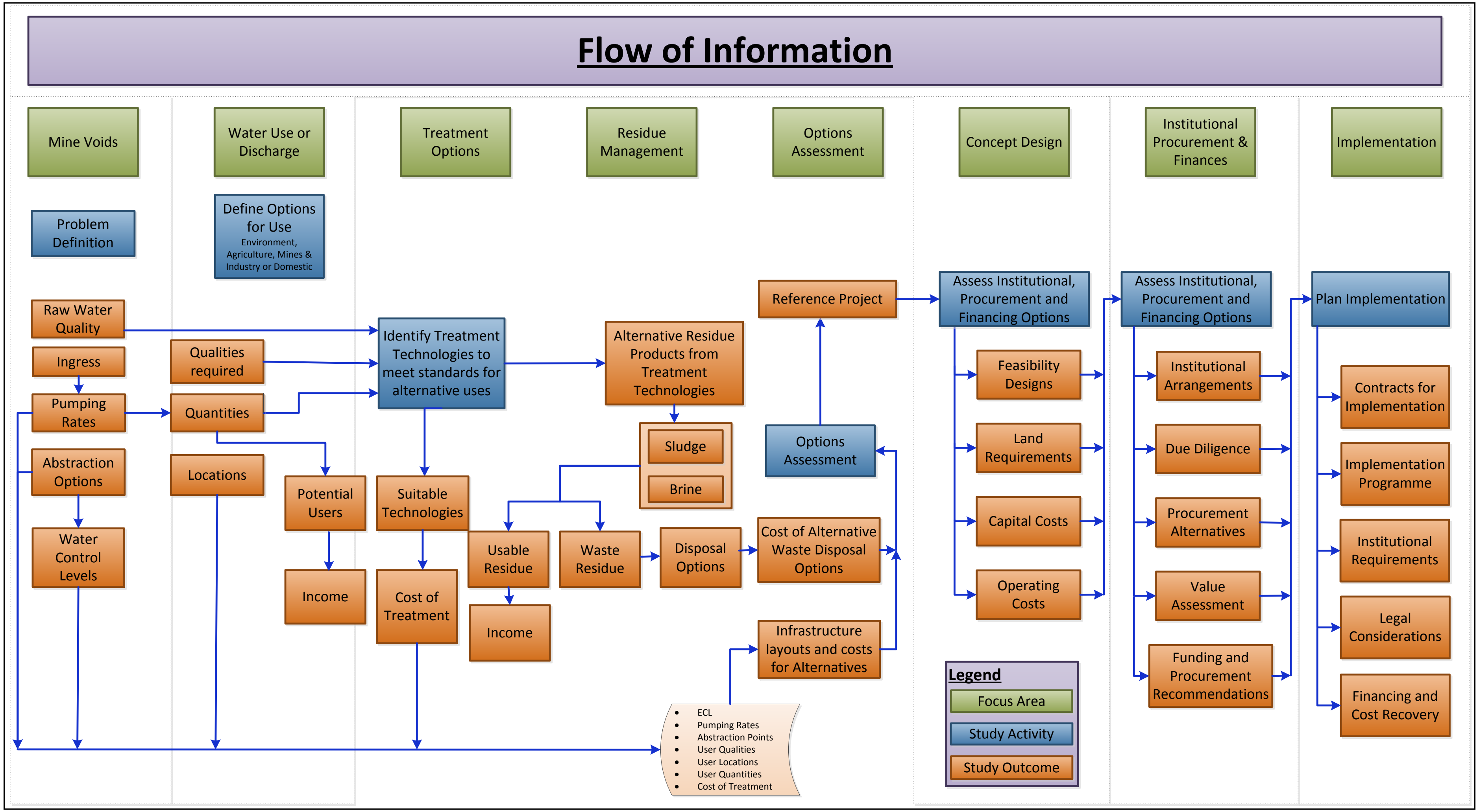

Figure 2: Flow of information throughout the Study

PHASE 1: Initiation

The objective of the Initiation Phase was to determine 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"***.

The Study Report No. 9.1: ***"Communication Strategy and Action Plan"*** was prepared so that key stakeholder engagement and communicators 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 the 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 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 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 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 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 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 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 the confidential Study Report No. 6: ***"Concept Design"***, the confidential Study Report No. 6.1: ***"Concept Design: Drawings"*** and the 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 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 the 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 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 Study Report No. 9: "***Key Stakeholder Engagement and Communications***".

The final deliverable, 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 National Treasury for their review and approval. The project has been registered with National Treasury, 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 "xxvi" and "xxx" respectively.

APPROVAL

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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, Ekhuruleni 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:
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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

This Study is to investigate the possible options for the long-term solutions for the Acid Mine Drainage (AMD) problem in the study area. The long-term solution (LTS) to be implemented must take account of the recommendations made in the Inter-Ministerial Committee (IMC) report, as well as the subsequent Trans-Caledon Tunnel Authority (TCTA) Due Diligence Report and the TCTA tender design.

The IMC Report in particular provide a good concise summary of AMD related challenges in other countries and the approaches those countries follow to address it. Other countries that are discussed in the IMC Report include Australia, Canada, United States of America and Germany.

The TCTA Due Diligence Report proposed the following for each basin:

Western Basin – Abstraction to take place from Rand Uranium Shaft No. 8. A new water treatment plant located at Randfontein Estates and treated water to be discharged into the Tweelopies Spruit. The waste disposal for the short-term will be to the Mogale West Wits Pit via the Training Centre Pit. The long-term waste disposal as identified by the Short-Term Intervention (STI) will potentially be either co-disposal with mines, disposal into the Western Basin mine void or a greenflieds engineered facility.

Central Basin – Abstraction from South West Vertical (SWV) Shaft, to lower water level to either the Environmental Critical Level *(ECL) or the Central Rand Gold (CRG) proposed mining level of 400 m below surface. Construction of a new High Density Sludge (HDS) plant at SWV, waste sludge pipeline to the Durban Roodepoort Deep (DRD) Gold (Crown) Knights Gold Plant, and also a treated water pipeline to a suitable discharge point on the Elsburgspruit. Waste disposal for the short-term is co-disposal on the ERGO Brakpan Tailings Storage Facility (TSF) for which an agreement was reached in December 2012. The long-term waste disposal as identified by the STI will potentially be either disposal to the ERGO Brakpan TSF, disposal into the Central Basin mine void or a greenflieds engineered facility.*

Eastern Basin – Abstraction to take place from Grootvlei No. 3 Shaft and pump to the ECL or to the level that will allow Gold One to continue mining at Sub-Nigel No. 1 Shaft. Construction of a new HDS treatment plant at No. 3, sludge pipeline to DRD Gold (Crown) Daggafontein TSF, treated water pipeline to the Blesbokspruit, and a future sludge pipeline to the ERGO Brakpan TSF (if required).

The STI tender design added the following details to the information provided in the Due Diligence report:

Western Basin – TCTA / Department of Water Affairs (DWA) have procured deep mine dewatering pumps, riser pipes and variable speed drives under a supply and install contract. The tender documentation is unclear whether both the new pumps will be used as duty pumps, or if one will be a standby pump. Since issuance of the tender documentation it has been determined that two pumps have been procured, of which one will act as duty pump and the second as standby pump

The Western Basin's average ingress flow, as per the TCTA Due Diligence Report, is estimated at 27 Mℓ/d. However, because the basin is already decanting, an average pumping rate of 34 Mℓ/d will have to be maintained to draw the water level down to the ECL which is 165 m below surface according to the TCTA Due Diligence Report. The proposed abstraction shaft has however been re-surveyed and a new collar level of 1 726 m amsl was determined, which would give a depth of 176 m below surface.

For the primary treatment of the immediate solution it was recommended that the existing Rand Uranium Treatment Plant be upgraded by adding another two treatment modules. The neutralised water will be discharged into the Tweelopies Spruit which forms part of the Crocodile West River System. The sludge generated by the treatment process will be pumped to the West Wits old opencast pit.

For the STI, the construction of a new HDS AMD treatment plant, with a capacity of 27 Mℓ/d has been proposed, although this has been put on hold due to budgetary constraints. Proposals have been received from Mintails South Africa that could postpone this expenditure until reworking of the tailings is complete

Central Basin – As was the case in the Western Basin, TCTA / DWA have obtained deep mine dewatering pumps, riser pipes and variable speed drives under an agreement with CRG. It is unclear from the tender documentation if both the new pumps will be used as duty pumps, or if one will be a standby pump. Since issuance of the tender documentation it has been determined that both pumps will act as duty pumps

The average ingress flow as per the TCTA Due Diligence Report is estimated at 57 Mℓ/d and the maximum ingress is estimated at 84 Mℓ/d, which are also the average and maximum pumping rates required.

A new HDS plant with a capacity of 72 Mℓ/d has been proposed for this basin and neutralised water will be discharged into the Elsburgspruit, which is within the Vaal River catchment. The sludge generated by the treatment process will be pumped to the DRD (Gold) Knights Tailings plant.

Eastern Basin – The tender documents indicate that four pumps are to be procured, with three to be installed as duty pumps. No pumps have been ordered yet, since that specification of the pumps are not yet finalised and will depend on whether Gold One will continue to mine in this basin or not.

The average ingress flow, as per the TCTA Due Diligence Report, is estimated at 82 Mℓ/d and the maximum ingress is estimated at 110 Mℓ/d, which are also the average and maximum pumping rates required.

A new HDS plant with a capacity of 84 Mℓ/d has been proposed for this basin and the neutralised water will be discharge into the Blesbokspruit. The sludge generated by the treatment process will be pumped to the ERGO Gold processing plant, before final disposal at the Brakpan TSF.

The options considered for abstraction and primary treatment for the three basins appear to have resulted in a sound solution, but this will be revisited when considering the options for the long-term. With regards to the disposal of neutralised water, this is or will be discharged to Tweelopies Spruit, Elsburgspruit and Blesbokspruit for the Western, Central and Eastern basins respectively. For the LTS, the disposal of neutralised water to the environment is not sustainable and alternatives to this must be assessed.

The STI for the treatment of AMD in the three basins has the primary goal to stop decant in the Western Basin and protect the ECL in the other two basins. The AMD that has to be pumped to achieve this must be treated to a standard that can be discharged into the environment on a sustainable basis. One of the primary principles for process selection was that the selected process must be a proven technology and preferably be generic for all the basins. The STI identified HDS as the technology that must be implemented to achieve the short-term objectives. Some details of the processes in the HDS treatment, its risks and the suitability thereof are discussed in this report.

At the date of this report, the only proven technology deemed suitable for the desalination of neutralised AMD was Reverse Osmosis. This study will however investigate alternative treatment options for the long-term (Study Report No. 5.4: Treatment Technology Options).

The infrastructure for sludge management and disposal would most likely be adequate for a number of years into the LTS, with the exception of the combined infrastructure used for co-disposal of sludge from the STI and operating mines. The state of this has not been determined at the conceptual level, and hence poses a risk, as it may need to be replaced early on for the LTS. One aspect that has not yet been considered for waste management is the potential to recover useable products during the neutralisation stage.

The STI proposed to continue with the disposal of waste sludge to tailings dams, or open pits, or possibly as backfill into abandoned mine workings. This created a number of potential problems in the long-term, which should be addressed in the Environmental Impact Assessment for the STI. The environmental acceptability of the STI for the LTS is especially relevant in light of the National Environment Management Act 107 of 1998 (NEMA) Section 24G process which was being executed by Digby Wells Environmental Consultants at the date of the first draft of this report. However, it must be noted that this situation has since changed with the exemption and authorisation that have been granted for the STI in terms of *the National Environment Management Act 107 of 1998 (NEMA 107: 1998) GNR.543, which is seen as an integral part of the solution for AMD (refer to Annexure D).*

The entire system will be investigated holistically, taking into account capital, operational and maintenance costs for both the STI and LTS options to ensure that the best value for money at the lowest possible risk is obtained for the whole life-cycle of the project(s) to be implemented. This Feasibility Study will aim to influence the STI measures as far as it is possible, but the need for speedy implementation of the STI presents challenges to this study in this regard. It must be noted that there exists a risk that some of the STI infrastructure may not be compatible with the LTS to be proposed, and therefore might become redundant once the LTS infrastructure is commissioned. At the date of this report, construction on the Central Basin infrastructure for the STI has started, but not for the other two basins. Thus, the Feasibility Study for a Long-term Solution might still influence the STI infrastructure in the Western and Eastern Basins.

As for the implementation of the STI and LTS, whichever procurement strategy is selected for the LTS, the STI will place some constraints on the possible options available for the LTS.

If the procurement strategy for the LTS is that Government will fund the capital required and that DWA will be the operator, then DWA will take on the solution design and operational risk of the STI solution. In the case of the LTS being either a Design, Build, Operate, Maintain (DBOM), or Public Private Partnership (PPP) solution, then the Private Party will be expected to take over the STI.

The Private Party in taking over an existing solution and operational infrastructure will be constrained in the technical solution that it can offer. Furthermore, the level of risk that Government will be able to transfer to the Private Party will be constrained since the Private Party will be expected to take over the existing solution and operational infrastructure. However, an economic analysis would need to be undertaken to determine if the solution for the immediate and short-term was cost effective in the long-term given the existing infrastructure.

Recommendations on all aspects discussed here will be made in subsequent reports.

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LIST OF ACRONYMS

Alk	Alkalinity
AMD	Acid Mine Drainage
ARD	Acid Rock Drainage
BID	Background Information Document
BKS	BKS Group (Pty) Ltd
BRI	Black Reef Incline
CBD	Central Business District
CGS	Council for Geoscience
CRG	Central Rand Gold
Cond	Conductivity
CSIR	Council for Scientific and Industrial Research
DBOM	Design, Build, Operate and Maintain
DG	Director-General
DMR	Department of Mineral Resources
DRD	Durban Roodepoort Deep
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
ECL	Environmental Critical Level
EIA	Environmental Impact Assessment
ERPM	East Rand Proprietary Mines
HDPE	High-density Polyethylene
HDS	High Density Sludge
IMC	Inter-Ministerial Committee
LTS	Long-Term Solution
m amsl	metres above mean sea level
MPRDA (28:2002)	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
ND	Nominal Diameter
NEDLAC	National Economic Development and Labour Council
NEMA (107:1998)	National Environment Management Act, 1998 (Act No. 107 of 1998)
NEMWA (59:2008)	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)
NGO	Non-Governmental Organisation
NRV	Non-Return Valve
NWA (36:1998)	National Water Act, 1998 (Act No. 36 of 1998)
O&M	Operation and Maintenance
OPEX	Operating Expenditure
PPP	Public Private Partnership
PSC	Public Sector Comparator
RfI	Request for Information
RfQ	Request for Qualifications
RfP	Request for Proposals
RO	Reverse Osmosis
RWQO	Resource Water Quality Objectives
SAC	Study Administration Committee
SMC	Study Management Committee

SoW	Scope of Work
SRK	SRK Consulting (Pty) Ltd
SSC	Study Stakeholder Committee
STI	Short-Term Intervention
SWV	South West Vertical
TA 1	Treasury Approval 1
TCTA	Trans-Caledon Tunnel Authority
TDS	Total Dissolved Solids
ToR	Terms of Reference
T&T	Turner & Townsend
TSF	Tailings Storage Facility

LIST OF CHEMICAL CONSTITUENTS

Al	Aluminium
Ca	Calcium
$CaCO_2$	Alkalinity
$CaSO_4$	Gypsum
Cl	Chloride
Fe	Iron
Mg	Magnesium
Mn	Manganese
Na	Sodium
O_2	Dissolved Oxygen
SO_4	Sulphate
U	Uranium

UNITS OF MEASUREMENT

µg	Microgram
A	Annum
C	Celsius
Cm	centimetre
D	day
dS	decisiemen
Ha	hectare
ℓ	litre
M	metre
m^3	cubic metre
Mg	milligram
Mℓ	megalitre
Mm	millimetre

GLOSSARY OF TERMS

Adit	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.
AMD	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.
Amphoteric	A molecule or ion that can react as an acid as well as a base.
Annexure	Documents produced by others attached to the report.
Appendix	Documents produced by the Feasibility Study attached to the report.
Aquifer	Zone below the surface capable of holding groundwater.
Brownfields	Abandoned or underused industrial and commercial facilities available for re-use.
Central Basin	Central Rand underground mining basin.
Catchment Vision	The visioning process enables the DWA to formulate an initial statement (i.e. the catchment vision) about a desired future state of the water resource on behalf of the catchment community and other interested parties
Decant (surface)	Spontaneous surface discharge of water from underground mine workings.
Decant (subsurface)	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.
Discharge (groundwater)	Seepage of groundwater at the surface.
Eastern Basin	East Rand underground mining basin.
Environmental Critical Level	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.
Feasibility Study	An analysis and evaluation of a proposed project to determine if it is technically sound, socially acceptable, and economically and environmentally sustainable.
Freeboard	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.

Greenfields	An undeveloped site, especially one being evaluated and considered for commercial development or exploitation.
Groundwater	Water occupying openings below surface
Immediate Solution	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.
Key stakeholder	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.).
Layout	The arrangement or configuration (site layout, pipe route, etc.) of a specific option.
Long-Term Solution	A solution that is sustainable in the long term with regards to the technical, ecological, legal, economic, financial and institutional aspects.
Mine plan	Accurate drawing showing the positions of mine excavations.
Option	One of a number of combinations of abstraction works, treatment processes, and solutions for the disposal of waste and utilisation of treated water.
Preferred option	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.
Ramsar Convention	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.
Reef	Term used on the Witwatersrand mines for conglomerate containing gold deposits.
Reference Project	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.
Reserve	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.
Resource Classification	The Classification System provides guidelines and procedures for determining the different classes of water resources. There are three Management Classes, namely "minimally", "moderately", and "heavily used". They describe the desired condition of the water resource and the extent to which it can be utilised.
Resource Quality Objectives	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.
Resource Water Quality Objectives	Is 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).
Request for Information	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.
Request for Qualifications	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.
Request for Proposals	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
Scenarios	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.
Service Provider	The generic term for the Special Purposes Vehicle (SPU) or contracting consortium that will design, build, operate and maintain and possibly finance the works.
Short-Term Interventions (Short-Term Solution as stated in Terms of Reference)	Emergency measures that are being implemented by the 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.
Socio-Economic Critical Level	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.
Target Operating Level	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.
Water table	The level in an aquifer below which the said aquifer are filled with water.
Western Basin	West Rand underground mining basin.

1 INTRODUCTION TO THIS REPORT

1.1 Report Objectives

The objective of this report is to describe the current and expected status of the technical management of Acid Mine Drainage (AMD), primarily within the study area. In particular the proposed Short-Term Intervention (STI) and its implications are reviewed.

Based on literature that is readily available the report provides an overview of the management of AMD nationally and internationally, to put the AMD problem in the Witwatersrand into perspective.

1.2 Structure of Report

The report is structured to cover the following aspects:

- Preface – This short project summary gives a brief overview of the entire study and indicates how all the study components and deliverables relate to each other.
- An overview of the national and international management of AMD;
- The Infrastructure proposed by the STI and the implications for LTS;
- Consideration for the long-term neutralisation of AMD;
- Environmental aspects; and
- Implications of the STI for procurement of the LTS

This report thus sets the scene and provides a common understating of the STI for the detailed investigations that follow. It also highlights some key issues that must be addressed.

Separate reports on the water quality and quantity of the mine voids, the options for use or discharge of water, the options for management of the residues from the waste and treatment technology options are also deliverables for the Feasibility Study.

1.3 International Experience in the Management of AMD Problems

Acid mine drainage is a significant and costly environmental impact of the mining industry worldwide. The legacy of mining continues to affect surface and groundwater resources long after mining operations have ceased. AMD is a common problem at abandoned mine sites around the world today. The oxidation of sulphur-rich mine wastes by interactions with water and oxygen and the consequent release of AMD (also called acid rock drainage, or ARD) is one of the main environmental challenges facing the mining industry. Many metallic ores contain significant amounts of sulphide minerals, particularly pyrite (FeS_2). Mining often exposes large amounts of pyrite and other sulphide minerals to the effects of water and oxygen once waste rock and tailings are produced on surface. The excavation process also exposes sulphides in the walls of opencast and underground operations, and disturbs the host rock and hydrological regime around mined out areas, allowing the ingress of water and oxygen.

It has been estimated that the cost of managing AMD at operating mines in Australia amounts to US $60 million per year (Harries, 1997). However, the management of potentially acid generating wastes is an important environmental issue as major costs may arise late in mine life or after mine closure if proper waste management strategies are not followed. The Australian Government estimates that when AMD is discovered after mine closure the cost of remediation can be as much as US $100 000 per hectare (Harries, 1997). The estimated cost of remediation in Canadian mine sites is three to four times (US $2 billion to US $5 billion) greater than for Australian sites (Harries, 1997).

1.3.1 Acid Mine Drainage in Australia

In 1995, the Australian and New Zealand Mineral and Energy Council (ANZMEC) published a baseline environmental guideline for operating mines in Australia. As part of the guideline acid generation should be predicted and incorporated in the mine closure plan (ANZMEC, 1995). In order to better understand the impact of AMD in Australia and to provide the basis for assessing long-term management options, the Office of the Supervising Scientist and the Australian Centre for Minesite Rehabilitation Research initiated the preparation of a status report on AMD (Harries, 1997).

1.3.2 Acid Mine Drainage in Canada

The Canadian Mine Environment Neutral Drainage (MEND) programme was established by mines and provincial, territorial and federal government agencies in 1989 in response to the recognition of AMD being the main environmental problem facing the Canadian mining industry. Mines in Canada were required to establish trust funds to cover the cost of the effect of AMD from mine wastes. A survey of metal-mine and industrial-mineral tailings in 1994 showed that of the 7 billion tons of tailings and 6 billion tons of waste rock, 1.9 billion tons of tailings and 750 million tons of waste rock were potentially acid generating (MEND, 1995).

1.3.3 AMD in the USA

The main AMD problem identified in the United States of America (USA) was the impact of acid drainage from coal mines on the streams in the eastern states. An estimated 7 000 km of streams were affected (Ferguson and Erickson, 1988). In total between 8 000 and 16 000 km of streams in the USA are affected by AMD (USEPA, 1995). Owing to the large potential liability of AMD from abandoned mines, the regulators insist on payment of performance bonds.

In the USA abandoned mines are rehabilitated under the National Abandoned Mine Land Programme under the Office of Surface Mining Reclamation and Enforcement (OSMRE) of the US Department of the Interior. Funds are raised via a levy on active coal mines and deposited into the Abandoned Mine Lands (AML) fund — a trust administered by the U.S. Treasury (Office of Surface Mining, 2006) to pay for reclamation of mines abandoned before the passage of the Surface Mining Control and Reclamation Act of 1977 (Wikipedia, 2007).

In line with most USA environmental legislation and regulation, the principle of cooperative federalism, whereby the American states take initiatives and the Federal Government oversees these efforts, is applied (Wikipedia, 2007). The State and tribal authorities taking responsibility for these efforts agreed in 1993 to form the National Association of Abandoned Mine Lands Programmes in order to coordinate these efforts, share knowledge and foster positive cooperation between themselves (National Association of Abandoned Mine Lands Programmes, undated).

Additional programmes have been instituted by the US Geological Survey, looking at hard-rock mining sites at a catchment scale in Colorado and Montana (United States Geological Survey, 2007) and the Bureau of Land Management, which oversees abandoned mines on public land (Bureau of Land Management, 2008).

1.3.4 Managing Uranium Mining Legacies in Germany

Following the reunification of Germany in 1990, it became clear that huge legacies existed owing to the mining of uranium in the former East German states of Saxony and Thuringia, including AMD impacts at some mines. These were addressed by the formation of a Federal-owned company — Wismut Gmbh. The mining legacy included 1 400 km of open mine workings, 311 million m^3 of waste rock, and 160 million m^3 of radioactive sludge (tailings) located in densely populated areas (Wismut, 2008). To this end a fund of €6.6 billion (later revised to €6.2 billion) was established under the 'Wismut Act, passed by the Federal Parliament in 1991 (Hagen and Jakubick, 2006).

While this has been extremely costly, the Wismut rehabilitation exercise has stimulated the economy in a relatively economically depressed area of Germany, creating 2 000 jobs and injecting approximately €100 million per annum into the local economy via tenders issued. A specific focus has been on the identification and stimulation of local small and medium contractors (Wismut, 2008).

Other spin-offs have included the development of expertise and technologies in local research institutions and consulting groups, which can now be transferred to other areas 6 and have been successfully applied in Central and Eastern Europe, Russia and Central Asia (Hagen and Jakubick, 2006). An important focus of the programme has been the productive utilisation of reclaimed areas and, while some land-uses obviously must be restricted, a number of successful projects have been undertaken.

1.3.5 Comparison of International Examples with the South African Situation

The key factors which differentiate the developing problem in South Africa from the international examples cited and identified is the degree of interconnection of large voids, the sheer scale of the Witwatersrand operations and the fact that many of the problem areas are located in or close to major urban centres. This necessitates large-scale programmes to address the problem of acid mine drainage. In other countries, mine flooding was planned to minimise impacts, while in South Africa this has not been done and, in many cases, this would not have been possible owing to closure of older mines within a basin long before flooding was contemplated. The matter is exacerbated by the untimely closure of most of the mines within each of the basins.

International experience reveals a number of factors that leads to the successful implementation of programmes dealing with mining legacies, including AMD:

- Acceptance that there is a problem that needs to be addressed in a coordinated programme between government and the mining industry;
- High-level coordination between a range of stakeholders, with government playing the leading role;
- Decisive action by the State to secure and provide funding; and
- On-going research to provide optimal and sustainable short-, medium- and long-term solutions.

2 INFRASTRUCTURE

2.1 Overview of Due Diligence Report for the Short-Term Interventions

The TCTA Due Diligence Report (2011) was compiled for the neutralisation of AMD and outlined proposals for each basin (refer to Appendix A for a base map of the three basins) regarding AMD abstraction, water treatment, treated water discharge and sludge disposal. The options proposed for implementation in the short-term are summarised below. For information on the procedure on how these options were selected, the TCTA Due Diligence report should be consulted.

2.1.1 Western Basin

The Western Basin requires immediate mitigation measures to neutralise AMD. This includes the upgrade and refurbishment of the Rand Uranium Treatment Plant. On instruction from DWA, this is being implemented as immediate measures (see Annexure A).

The option proposed for STI in the Western Basin for the STI consists of the following components:

- Abstraction from Shaft No. 8;
- A new water treatment plant located at Randfontein Estates (west of Azaadville);
- Treated water discharge into the Tweelopies Spruit, flowing into the Crocodile West River; and
- Waste Sludge Disposal Sites:
  - i) Short-Term:
    - Mogale West Wits Pit (3 to 5 years); and
    - Training Centre Pit (one year).
  - ii) Potential Long-Term:
    - Agreement with mining companies to co-dispose of sludge, sharing a tailings storage facility;
    - Disposal into the Western Basin mine void; and
    - Greenfields engineered disposal facility.

2.1.2 Central Basin

The option to be implemented for the Central Basin for the STI comprises:

- Abstraction from South West Vertical (SWV) Shaft to either pump to the ECL or to the Central Rand Gold (CRG) proposed mining level of 400 m below the SWV shaft collar level;
- Construction of a new High Density Sludge (HDS) plant, located at SWV Shaft;

- The phased construction of the HDS plant, which will allow for phased commission thereof;
- Construction of a waste sludge pipeline to the Durban Roodepoort Deep (DRD) Gold (Crown) Knights Gold Plant;
- Construction of a treated water pipeline to a suitable discharge point on the Elsburgspruit;
- Waste Sludge Disposal Sites:
- Short-term:

  Construction of a pumping main to the existing DRD Gold Knights gold processing plant (five to six years). The sludge will then be co-disposed of on the ERGO Brakpan Tailings Storage Facility (TSF).

  i) Potential Long-term:
    - Pumping main to the ERGO Brakpan TSF (DRD Gold has indicated that the life of this facility is in excess of 30 years);
    - Disposal into the Central Basin mine void; or
    - Greenfields engineered disposal facility.

The following aspects were required before the engineering design could be finalised:

- A decision on the pumping depth, i.e. ECL or the CRG proposed level;
- Agreement or procurement of required land and servitudes;
- A topographical survey of recommended sites and pipeline routes; and
- A geotechnical investigation of the recommended sites and pipeline routes.

2.1.3 Eastern Basin

Existing infrastructure:

- A sludge pipeline to the DRD Gold (Crown) Daggafontein TSF; and
- A water pipeline for discharge of neutralised water to the Blesbokspruit (short-term discharge).

The option to be implemented for the STI for the Eastern Basin requires the following:

- Pumps to be installed at Grootvlei No. 3 shaft at the depth required to maintain the water level below the ECL or the level to allow Gold One to continue mining Sub-Nigel No. 1 Shaft;
- Construction of a new HDS treatment plant adjacent to the Grootvlei No. 3 shaft, on the agricultural small holding site south of the abstraction point; and
- A future sludge pipeline to the ERGO Brakpan TSF is planned (if required).

The aspects that were required to proceed with the design are:

- A decision on the pumping depth, i.e. ECL or the Gold One mining requirements, possibly 530 m below surface at Grootvlei No. 3 shaft;
- Agreement on or procurement of required land and servitudes;
- A topographical survey of recommended sites and pipeline routes; and
- A geotechnical investigation of recommended sites and pipeline routes.

It must be noted that these proposals for the STI, as set out in the TCTA Due Diligence Report 2011 were not final yet and were subject to change. The final solutions to be implemented for the STI as included in the tender documentation, prepared by the consultants for the neutralisation of AMD, are described in the following sub-section.

2.2 Overview of Tender Design

For more information on the tender design of the STI, the tender documents (TCTA Tender Documents 2011) should be consulted.

2.2.1 Abstraction Works

a) Western Basin

A map indicating the proposed Short-Term Intervention for the Western Basin has been included as **Appendix B**. In the Western Basin, the AMD abstraction pump station is located at Rand Uranium Shaft No. 8, which is located approximately 1.5 km to the west of the R28 (Main Reef Road). The shaft was used for the abstraction of mine water for many years and was in use until fairly recently. It has two conveyances, of which one is currently occupied by pipes and pumps for abstraction of AMD to the existing Rand Uranium treatment plant to the west of Shaft No. 8. The remaining conveyance will be used for installation of the new pumps.

According to information included in the tender documentation for the STI, TCTA/DWA have procured deep mine dewatering pumps under a supply and install contract. The pumps and equipment ordered for the Western Basin are:

- 2 x Ritz Model HDM 6737/3 submersible pumps each with Non-Return Valve (NRV), cooling shroud and 250 m electrical cable;
- 2 x 250 m riser pipes, nominal length between 8 m and 12 m; and
- 2 x Variable Speed Drives (Allen Bradley).

According to the TCTA Due Diligence Report, two duty pumps and one standby pump (not fitted) are to be installed at Shaft No. 8. The tender documentation does not confirm if this will be the final configuration or whether the two new pumps that have been procured will both be duty pumps or if only one will be used as a duty pump with the other as standby. It was also not specified whether the existing pump in the shaft will be used as a standby or a duty pump. Since the issuance of the tender documentation the TCTA has confirmed that the abstraction point in the Western Basin will have only one duty pump with one standby pump. Due to budgetary constraints tenders have not been awarded and some alternatives are now being considered.

Because the basin is already decanting, an average pumping rate of 34 Mℓ/d will have to be maintained to draw the water level down to the ECL which is 165 m below surface as per information received from TCTA. The average ingress flow, as per the TCTA Due Diligence Report, is estimated at 27 Mℓ/d and the maximum ingress (and also the maximum pump flow rate) is estimated at 35 Mℓ/d. This average ingress value is more conservative than the 23 Mℓ/d that was determined in Study Report No. 5.2: *"Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids"*. The pumps have to be capable of pumping these flows at a head of up to 215 m.

The riser pipes in the shaft will be 400 mm Nominal Diameter (ND) stainless steel (DIN 1.4462 or U-2205) pipes of approximately 10 m in length. No drawings of a superstructure at Shaft No. 8 were provided, since the existing infrastructure will be used.

b) Central Basin

A map indicating the Central Basin and the proposed STI has been included as **Appendix C**. The proposed AMD abstraction pump station and treatment works will be located at the East Rand Proprietary Mines (ERPM) Shaft. This shaft was used as a major pumping shaft until 2008. Buildings in the area of the shaft have been demolished to ground level and the below ground concrete foundations and services have been removed.

TCTA/DWA have procured deep mine dewatering pumps under an agreement with CRG for the Central Basin. The pumps and equipment included under this agreement with CRG for the Central Basin are:

- 2 x Ritz HDM 6737/3-15 submersible pumps each with a NRV, cooling shroud and 450 m electrical cable;
- 2 x 420 m riser pipes, nominal length between 8 m and 12 m; and
- 2 x Variable Speed Drives (Allen Bradley).

According to the TCTA Due Diligence Report, there will be two duty pumps and one standby pump (not installed) at the SWV Shaft. This configuration is confirmed by the drawings of the shaft pump station included in the tender documents for the STI. It is unclear whether the two new pumps that have been obtained will both be duty pumps or if only one of them will be used as a duty pump with the other as standby.

The average ingress flow as per the TCTA Due Diligence Report is estimated at 57 Mℓ/d and the maximum ingress is estimated at 84 Mℓ/d. This average ingress is more conservative than the 46 Mℓ/d that will be presented in Study Report No. 5.2 *"Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids"* of this study. These are also the average and maximum pumping rates required to maintain the ECL at 186 m below surface. However, the pumps at SWV Shaft have to be capable of pumping these flows at a head of up to 400 m, depending on future mining operations that might or might not be undertaken by CRG.

The riser pipes in the shaft will be 400 mm ND stainless steel (DIN 1.4462 or U-2205) pipes of approximately 10 m in length. Drawings of the superstructure of the abstraction pump station were provided by the consultants for the neutralisation of AMD, as part of their Tender documentation.

c) Eastern Basin

A map indicating the Eastern Basin and the proposed STI has been included as **Appendix D**. The proposed AMD abstraction pump station and treatment works will be located immediately adjacent to the Grootvlei Shaft No. 3. The shaft is divided into six (6) compartments, with one being used for services and the other five (5) for conveyances.

According to the TCTA Due Diligence Report, three duty pumps will be installed at Grootvlei Shaft No. 3, with a standby pump being procured, but not be installed. This configuration is confirmed by the drawings of the shaft pump station, included in the tender documentation for the STI. The selection of the pumps will depend on confirmation by Gold One on whether they will continue mining in the basin or not. No pumps have yet been ordered by either TCTA or any of the mines.

The average ingress flow, as per the TCTA Due Diligence Report, is estimated at 82 Mℓ/d and the maximum ingress is estimated at 110 Mℓ/d. This average ingress value is only slightly more conservative than the 80 Mℓ/d that will be presented in Study Report No. 5.2 **"Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids"**. These are also the average and maximum pumping rates required to maintain the ECL of 290 m below surface, as per information received from TCTA. The pumps in Grootvlei Shaft No. 3 must be capable of pumping the abovementioned flows at a head of up to 530 m, depending on future mining operations that might or might not be undertaken by Gold One.

2.2.2 Primary Treatment

a) Western Basin

Immediate Solution

The fact that AMD is already decanting in the Western Basin at the Black Reef Incline and 17 and 18 Winze, coupled with the fact that the volume of AMD exceeds the current capacity of Rand Uranium's treatment plant, means that immediate remedial measures are necessary. It was therefore proposed that this current conventional lime neutralisation plant be refurbished and an additional two treatment modules be added to the existing one. The capital expenditure of this refurbishment amounts to approximately R25 million and the plan is to keep the plant running after the new HDS plant has been constructed as part of the STI, but only until the ECL has been reached.

Short-Term Intervention

The construction of a new HDS AMD treatment plant has been proposed. The proposed site for the works lies on Rand Uranium land and is accessible from Main Reef Road. It is bounded on the north by the TSF No. 38. The proposed 27 Mℓ/d treatment works will cover an area of approximately 4 hectares.

b) Central Basin

For the Central Basin (as for the Western Basin), a new HDS plant has been proposed. The proposed AMD treatment facility is situated about 1.8 km east of the Germiston Central Business District (CBD), on the western portion of the ERPM SWV Shaft, on land owned by DRD Gold. The 72 Mℓ/d treatment works will cover an area of approximately 4 hectares around the shaft.

c) Eastern Basin

For the Eastern Basin, a new HDS plant was also proposed. The proposed treatment facility will be situated at the Grootvlei Mine Shaft No. 3, adjacent to the AMD abstraction pump station. The site is located approximately 4.6 km due east of the Springs CBD. The 84 Mℓ/d treatment works will cover an area of approximately 4 hectares around the shaft.

2.2.3 Discharge of Neutralised Water

The discharge of neutralised water will comply with the Directive that was issued to TCTA in this regard (Annexure C).

a) Western Basin

A 6.8 km long, 700 mm diameter HDPE pipeline will discharge neutralised water into the Tweelopies Spruit just north of the R24, which is downstream of the Hippo Dam. The Tweelopies Spruit forms part of the Crocodile West River system.

b) Central Basin

A 1.7 km long, 1 000 mm diameter concrete pipeline will discharge the neutralised water into the Elsburgspruit, which is within the Vaal River catchment.

c) Eastern Basin

The 0.7 km 900 mm diameter concrete treated water pipeline will discharge neutralised water into the Blesbokspruit.

2.2.4 Waste Management

The management of waste will comply with the Directive that was issued to TCTA in this regard (**Annexure B**).

a) Western Basin

Sludge will be disposed of by means of a 200 mm diameter, 4.2 km long High-Density Polyethylene (HDPE) sludge delivery pipeline that will transport the sludge from the HDS plant to the West Wits old opencast pits.

b) Central Basin:

Sludge will be disposed of by means of a 250 mm diameter, 3.6 km long HDPE sludge delivery pipeline that will transport the sludge from the HDS plant to the DRD Gold (Crown) Knights tailings plant.

c) Eastern Basin

Sludge will be disposed of by means of a 300 mm diameter, 15.3 km long HDPE sludge delivery pipeline that will transport the sludge from the HDS plant to the ERGO Gold processing plant, before final disposal at the Brakpan TSF.

2.3 Assessment of Sustainability of STI

2.3.1 Abstraction Works

The options considered for the STI appear to have resulted in a sound solution. However, alternative solutions with respect to pumping systems will also be assessed. The abstraction works will be investigated holistically taking into account capital, operational and maintenance costs for both STI and LTS options.

2.3.2 Primary Treatment

The options considered for the STI appear to have resulted in a sound solution. However, alternative solutions with respect to primary treatment will also be assessed.

2.3.3 Discharge of Neutralised Water

The previous studies considered the release of neutralised water into defined watercourses. These are identified as the Tweelopies Spruit, Elsburgspruit and Blesbokspruit for the Western, Central and Eastern Basins, respectively. Even though a small quantity of neutralised water is discharged into the environment, compared to the much higher calculated flood volumes, the discharge of the neutralised water will be over a continuous period and the impact on the existing river conditions needs to be quantified before this option can be considered as viable. It is only envisaged as a short-term temporary measure, but is not considered viable for the long term.

They hydraulic impact of discharging neutralised water into the three defined watercourses is shown in **Table 2.1**.

Table 2.1: Hydraulic Impact of Neutralised Water Discharge

Basin	Western		Central		Eastern	
Water Course	Tweelopies-Spruit		Elsburgspruit		Blesbokspruit	
	m^3/s	Mℓ/d	m^3/s	Mℓ/d	m^3/s	Mℓ/d
1 in 25 year flood volume (natural)	28	2 419	96 - 182	8 294 – 15 725	429 - 600	37 066 – 51 840
1 in 100 year flood volume (natural	37	3 197	125 - 237	10 800 – 20 477	543 - 761	46 915 – 65 750
1 in 200 year flood volume (natural)	46	3 974	154 - 291	13 306 – 25 142	655 - 918	56 592 – 79 315
Maximum additional discharge	0.405	35	0.972	84	1.270	110
Calculated rise in flood water level	0 – 10 mm		No change in water level		0 – 10 mm	

The sustainability of the STI described in the TCTA Due Diligence Report 2011, TCTA Tender Documents 2011 and other reference material made available was investigated. It was concluded that it is an appropriate solution as an emergency and short-term measure that will comply with the Directive issued to TCTA. However, alternative solutions with respect to the treatment of raw AMD the disposal of neutralised water and desalination will also be assessed for the LTS. The entire system will be investigated holistically, taking into account capital, operational and maintenance costs for both the STI and LTS options to ensure that the best value for money at the lowest possible risk is obtained for the whole life-cycle of the project(s) to be implemented.

2.3.4 Discharge of Neutralised and Desalinated Water

A meeting with Rand Water was held to discuss their utilisation of neutralised and desalinated (fully treated) AMD water and the initial finding is that Rand Water does not support introducing fully treated AMD water into their potable system. They would, however, consider alternative options besides being supplied with potable water (e.g. industrial grade water). Rand Water is the single largest bulk water services provider in South Africa that could benefit and further discussions will be held to pursue this further.

Discussions with other stakeholders such as Magalies Water and the Municipalities still need to be initiated.

2.3.5 Sludge Management and Disposal

The infrastructure for sludge management and disposal would most likely be adequate for a number of years into the Long-Term Solution, with the exception of the combined infrastructure used for co-disposal of sludge from the STI and operating mines. The state of this has not been determined at the conceptual level, and hence poses a risk, as it may need to be replaced early on for the LTS. The following also need to be addressed:

- Establish the long term performance of the sludge disposed of in a permanent facility;
- Establish the long term stability (physical and chemical) of sludge disposed of with tailings;
- Investigate the possibility of disposing of sludge in underground workings.
- Verify consolidation assumption (30%); and
- Consider the capacity of pipelines for co-disposal with gold tailings, especially after closure of the existing gold processing plants.

At a conceptual level the STI considers almost all aspects of the sludge disposal. Certain assumptions need to be verified, and the permitting/licensing process could be arduous and constraining. Final design, including TSF stabilities, monitoring and closure aspects, need to be done. TCTA has confirmed that arrangements have been concluded for the disposal of sludge until the LTS can be implemented. Co-operation and commercial arrangements with existing facility owners for the long-term sludge disposal need to be established and maintained.

Long-term liabilities, associated with the short-term sludge disposal actions, need to be addressed so that these liabilities are not assumed to be part of the LTS. This is with particular emphasis on the design liability for the LTS.

Based on historic, local and international practice for HDS disposal, the options put forward are not exceptional and the past history indicates that these options are sustainable into the future, provided that suitable commercial and technical arrangements are concluded.

2.3.6 Conclusion

The potential beneficiaries of neutralised AMD water, which would need to comply with potable, industrial standards or be equivalent to the raw water quality of the Vaal Dam, could consist of the following stakeholders, in part or in whole:

- Bulk water services providers (Rand Water, Magalies Water);
- Water Services Authorities (City of Tshwane, Ekurhuleni Municipality, etc.);
- Local and District Municipalities (Parys Local Municipality, Rustenburg Local Municipality, etc.);
- Industrial Users (Sasol, Eskom, etc.); and
- Discharge into watercourses.

3 NEUTRALISATION OF AMD

3.1 Objectives

The purpose of this section is to assess the proposed STI, as well as the implication/integration thereof, on the possible Long-Term Solution. The study for the STI conducted by BKS/Golder & Associates offers the HDS as process solution. It is a well-known process with several references. This document provides an overview of the STI, the risks associated with the STI, the potential integration thereof with the LTS, the expected sludge and product water qualities, as well as mobile desalination units amongst others.

3.1.1 Outcomes of the Chapter

The major outcomes of this chapter are the review of the proposed HDS process for the TCTA STI for the treatment of AMD from the Western, Central and Eastern Basins with regards to the following:

- Provide a simplified process description as background;
- Review the proposed process;
- Identify process risks of the treatment plant;
- Identify process risks for sludge handling;
- Undertake review of expected product water quality after treatment;
- Undertake review of uranium removal;
- Review the quantity and quality of the sludge that is expected;
- Evaluate staged precipitation, in order to recover low/no value sludge product;
- Assess suitability of HDS as pre-treatment to reverse osmosis desalination; and
- Assess applicability of mobile desalination treatment plants.

A separate report assesses treatment technology options for the LTS.

3.1.2 Basis of the Evaluation

The feed water capacities that require treatment are summarised below:

Table 3.1: Feed Water Capacity for each Basin

Witwatersrand Basins	Basis of Design		Plant Design	
	Average daily flow (Mℓ/d)	Maximum daily flow (Mℓ/d)	Average (Mℓ/d) for operation 19 hours per day	Maximum (Mℓ/d) for operation 24 hours per day
Western Basin	27	35	34	35
Central Basin	57	84	72	84
Eastern Basin	82	110	106	110

Source: TCTA Due Diligence Report 2011

The process design was based on the mine water quality, as provided below:

Table 3.2: Feed Water Quality Design Basis

Water Quality Parameter	Units	TCTA Due Diligence Report 2011		
		Western (95th percentile)	Central (95th percentile)	Eastern (flooded condition)
TDS	mg/ℓ	7 174	7 700	5 500
Conductivity	mS/m	548	730	450
Calcium (Ca)	mg/ℓ	461	580	550
Magnesium (Mg)	mg/ℓ	345	380	230
Sodium (Na)	mg/ℓ	139	150	325
Sulphate (SO_4)	mg/ℓ	4 556	5 200	3 275
Chloride (Cl)	mg/ℓ	65	260	260
pH	-	3.4-4.0	2.3 [(c)]	5
Acidity ($CaCO_3$)[(d)]	mg/ℓ	2 560	2 425	750
Iron (Fe)	mg/ℓ	933	1 000	370
Aluminium (Al)	mg/ℓ	54	50	1
Manganese (Mn)	mg/ℓ	312	60	10
Uranium (U)	mg/ℓ	0.2	--	--

Source: TCTA Due Diligence Report 2011

The specified product water quality as per Government Directive and a comparison thereof with SANS241:2011 standards are provided below:

Table 3.3: Product Water Quality Objective

Parameter	UOM	Government Directive*	SANS 241:2011	Comment to SANS241:2011
pH		6.5 – 9.5	5.0 – 9.7	
Conductivity (EC)	mS/m	≤350	≤170	
Sulphate (SO_4)	mg/ℓ	≤2 500	≤250	Aesthetic
			≤500	Acute Health
Aluminium (Al)	µg/ℓ	≤1 000	≤300	
Iron (Fe)	µg/ℓ	≤1 000	≤300	Aesthetic
			≤2 000	Acute Health
Manganese (Mn)	µg/ℓ	≤10 000	≤100	Aesthetic
			≤500	Acute Health
Uranium (U)	µg/ℓ	≤50	≤15	

** These values are as per the Directive issued on 7 November 2011 (Reference 16/2/7/C231/G003) to TCTA for the discharge quality of neutralised AMD into the Tweelopies Spruit (Annexure C).*

The product water quality from the HDS process will be described in more detail later.

3.1.3 Process Description

The proposed HDS process is described in detail in the *TCTA Due Diligence Report from BKS and Golder & Associates: Document "J01599 Process Design Final"*. A simplified process description of this STI is discussed in this section.

a) Primary Goals

The STI for the treatment of AMD in the three basins has the primary goal to stop decant in the Western Basin and protect the ECL in the other two basins. The AMD that has to be pumped to achieve this must be treated to a standard that can be discharged into the environment without any intolerable consequences. This would require, as a minimum, the following:

- Precipitation and removal of heavy metals (specifically iron (Fe), Manganese (Mn), Aluminium (Al) and Uranium (U);
- Neutralisation of acidity of mine water; and
- Reduction of the salt load by partial precipitation of high sulphates presents in mine water.

To achieve above mentioned it is crucial that monitoring must be on-going and that standard anion-cation analyses be conducted twice a year.

One of the primary principles for process selection was that the selected process must be a proven technology and preferably be generic for all the basins.

b) Important feed and product water characteristics

The estimated raw water feed compositions are shown in **Table 3.2** and the following must be noted:

- High Total Dissolved Solids (TDS) - With the proposed process (even operated at optimum conditions), the metals can be removed to less than 1 mg/ℓ respectively and SO_4 down to an estimated level of 2 100 mg/ℓ apart from neutralisation. Thus, based on the feed design basis, the best possible TDS value of the product water, if the plant is operated at optimum conditions (longer retention times and magnesium removal as well at higher pH than the proposed process), will be more or less (Western Basin shown as an example):
  - TDS (end) = TDS (start) – SO_4 (start) + SO_4 (end) – Fe (start) + Fe (end) - Al (start) + Al (end) - Mn (start) + Mn (end) – Ca (start) + Ca (end) – Mg (start) + Mg (end) = 3 336 mg/ℓ.
  - Based on the current process operating condition, the TDS value of the product water will be more than 4 000 mg/ℓ and the resultant electrical conductivity will be out of specification.
- Magnesium (Mg) - Magnesium will not be removed in the existing HDS process, but if the pH of the gypsum reactor is operated at a pH above 10.6, most of the magnesium will be removed. This would result in co-precipitation of silica and more effective SO_4

(Sulphate) removal. The higher pH will require higher lime dosages, and hence it will increase the OPEX.

- Sodium (Na) - Sodium is a monovalent ion and is highly soluble; sodium will not precipitate from the process. It is important that no, or as little as possible, sodium based salts are added to the process, as they usually increase the TDS of the waste stream;
- Sulphate (SO_4) – Sulphate is the major component of the feed stream. It is important to note that effective sulphate removal such as gypsum ($CaSO_4$) precipitate is influenced mainly by the following factors:
    - Higher concentrations of Mg, Na and K will negatively influence gypsum precipitation. These ions are associated with sulphates in preference to Calcium (Ca) and keep the sulphates in solution;
    - Seeding or gypsum crystal recycling rate has a positive effect on new gypsum crystal formation. Thus, sludge recycling is very important;
    - Longer reaction time increases sulphate removal such as gypsum. Three to four hours reaction time is recommended, depending on the reactor design and sludge recycling; and
    - Mixing intensity – a mixing intensity of about 40 W/m^3 is required. A too low mixing intensity will result in solids settling in the reactor and require regular maintenance thereof. Mixing too fast will inhibit crystal growth.
- Chloride (Cl) - Chloride is a monovalent ion and is highly soluble. Chloride will not precipitate from the process. It is important to add no or as little as possible chloride based salts to the process, as they usually increase the process waste stream and/or increase the TDS of the final waste stream;
- pH - The low pH value of the feed stream is characteristic of the acidity in the feed that has to be neutralised;
- Metals – Iron (Fe), manganese (Mn) and aluminium (Al) concentrations are all very high and the major metals found in the feed stream. The high metal concentrations are one of the major reasons why AMD is such a huge environmental risk. All these metals can effectively be removed from the feed stream by the proposed HDS process to levels of ~ 0.5-3 mg/ℓ. The HDS process can be modified fairly easily, without additional primary equipment changes, for more effective metal removal. These modifications include, amongst others:
    - Operating the gypsum reactor at a slightly higher pH of 9.5-10;
    - Dosing of an oxidising agent as a polishing removal step; and
    - Increasing the efficiency of aeration in the pre-neutralisation and neutralisation reactors.
- Uranium (U) – Uranium is radioactive and needs to be removed to less than 50 µg/ℓ. Lime softening (part of the HDS process) is able to decrease the Uranium to below or very close to these levels. A polishing ion exchange step might be required as a safety implication, but it is recommended to further investigate the efficiency of U removal by the HDS process first.

3.1.4 Simplified Process Description

The relationship between the processes described below is illustrated in the simplified process diagram, included as **Figure 3.1Error! Reference source not found.**.

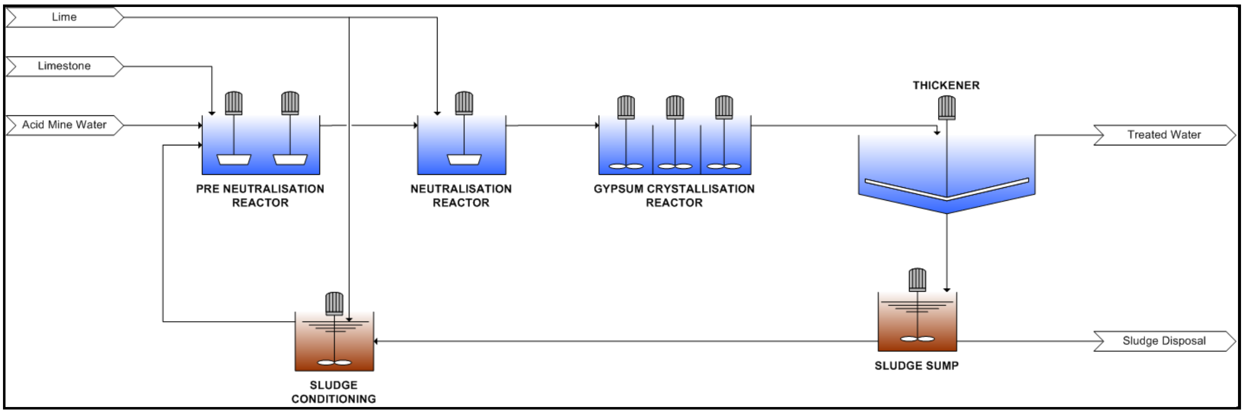

Figure 3.1: Simplified Process Schematic

a) Pre-neutralisation

The AMD feed is partially neutralised (reaction 1) to a pH of between 5.5 and 6 with a 10% limestone slurry. A large portion of the Al and Fe (III) is precipitated in this step (reaction 2). The reactions applicable to this process step are shown below:

$$2H^+ + CaCO_3 \rightarrow Ca^{2+} + CO_2 + H_2O \quad (1)$$

$$2M^{3+} + 3CaCO_3 + 3H_2O \rightarrow 2M\ (OH)_3\ (s) + 3CO_2 + 3Ca^{2+}\ (M = Fe, Al) \quad (2)$$

Aeration is used in the first part of the reactor for mixing and to drive off carbon dioxide (CO_2). CO_2 needs to be removed, in order to prevent the reaction downstream of lime and CO_2 (reaction 3), which would increase the chemical consumption significantly.

$$CO_2\ (g) + Ca\ (OH)_2 \rightarrow CaCO_3\ (s) + H_2O \quad (3)$$

Aeration is also required to oxidise Fe (II) to Fe (III). Although the reaction kinetics require a pH of at least 5.5 to 6, the water is brought closer to dissolved oxygen saturation limits in this step. Effectively though, the Fe (II) is only oxidised in the next step (neutralisation reaction). The reaction rate virtually doubles (or in other words the reaction time is halved) for each pH unit above 6.

It is important to note that as soon as gypsum ($CaSO_4$) reaches saturation with the addition of limestone, gypsum precipitation will start (reaction 3). Note that in all the reactions above Ca is only a spectator ion and does not participate in the reaction. Thus, the Ca concentration will rise, as limestone is added and take the water closer to gypsum saturation levels. The gypsum precipitation reaction (reaction 4), will only be partially completed as the slower reaction kinetics requires a reaction time of at least 3 hours. The design allows a retention time of 30 minutes in the pre-neutralisation reactor and therefore most of the gypsum crystallisation will take place in the preceding reactors.

$$Ca^{2+} + SO_4^{2-} \rightarrow CaSO_4\ (s) \quad (4)$$

No significant manganese precipitation/removal occurs in the pre-neutralisation step.

b) Neutralisation

In the neutralisation reactor quicklime (CaO) is slaked and dosed as 10% milk-of-lime slurry. In the neutralisation step, most of the remaining Fe and Al are precipitated. Aeration is once again used in the first part of the reactor for mixing and to drive off carbon dioxide (CO_2). Aeration is also required to oxidise Fe (II) to Fe (III) (reaction 5), which can then be removed as iron hydroxide (reaction 6) in the clarifiers.

$$Fe^{2+} + 0.25O_2 + H^+ \rightarrow Fe^{3+} + 0.5H_2O \quad (5)$$

$$Fe^{3+} + 1.5Ca(OH)_2 \rightarrow Fe(OH)_3\ (s) + 1.5Ca^{2+} \quad (6)$$

Fe (II) needs to be converted to Fe (III) mainly for the following reasons:

- Fe(II) does not precipitate at a pH lower than ~7.5 and effective removal thereof to the level required, only occurs at pH >8.5, while effective removal of Fe(III) already starts above pH 3.5; and
- Fe (II) causes armouring of the limestone particles, significantly reducing the reaction efficiency.

By dosing of lime, the pH is raised to 9 which causes manganese precipitation (reaction 7) and further improved gypsum precipitation (reaction 4).

$$Mn^{2+} + Ca(OH)_2 \rightarrow Mn(OH)_2\ (s) + Ca^{2+} \quad (7)$$

The design allows a retention time of 60 minutes in the pre-neutralisation reactor.

c) Gypsum crystallisation reactor

The purpose of the gypsum crystallisation reactor is to provide the additional required retention time for gypsum crystallisation. No dosing is performed in this stage, as the required calcium for sulphate removal via gypsum precipitation has already been added in the preceding steps. Slow mixing is provided in this stage to enhance crystal growth. The design allows a retention time of 120 minutes in the gypsum crystallisation step.

d) Clarifier

The precipitated species formed in the reactor steps are in a suspended form and are removed in a clarifier. The precipitated species are mainly metals and gypsum. The design up flow velocity in the clarifier is 1 m/hr. and the side wall depth is 4.5 m, which allows the suspended matter to settle out at the bottom of the clarifier. The settling of solids is further enhanced by the addition of a flocculant, which aids in agglomeration of small particles. The clarified water overflows at the top of the clarifier, where it is collected in the clarified water sump. This clarified water is the product water of the HDS process.

A sludge blanket forms at the bottom part of the clarifier. The feed which flows from the top of the centre well is introduced at the bottom of the centre well into the clarification zone below the sludge blanket. The sludge blanket almost acts as a filter and aids in settling of the solids.

The settled solids are scraped off the bottom of the clarifier cone to the extraction point in the centre and extracted from the clarifier as a sludge consisting of 7-14% suspended solids. A fraction of the sludge is routed back to the process (as discussed later) and the other fraction is bled off as waste, in order to control the amount of solids in the reactors.

e) Sludge conditioning tank

The recycled sludge from the clarifier is highly scaling and complete redundancy will be installed on the sludge recycle lines to allow for blockages to be cleared and/or maintenance. The recycled sludge is routed to the sludge conditioning tank where 40% of the lime is dosed in order to condition the sludge and improve its settling characteristics. The design allows for rapid mixing and a retention time of 30 minutes in the sludge conditioning tank.

f) Sludge recycling

From the sludge conditioning tank the recycled sludge is routed to the pre-neutralisation reactor again with the raw water. The recycled sludge contains a large fraction of gypsum, which is recycled to provide seeding, as crystal growth is enhanced if the nuclei already exist in the reactor.

3.1.5 Process Technology Overview

a) General

The HDS process and the different variations thereof is a proven technology on several applications, specifically where neutralisation of acidic water with high metal concentrations is required. The selected HDS process utilises limestone and lime as the major chemicals. With the HDS process, removal of monovalent species is not possible and the aim is to reduce the metals (specifically Fe, Mn, Al and U) to within the specified limits. With the addition of calcium to the water, an additional benefit is the partial removal of sulphates.

Based on the process information provided, the design in general appears to be adequate in terms of retention time, dosing requirements, mixing requirements etc. Specific equipment selection, materials of construction, valve and instrumentation selection, and detail control philosophy have not been evaluated.

b) Identification of risks

The risks or areas of concern are briefly discussed in this section. The responsibility for the process to meet the project requirements is solely that of the relevant contractor(s).

c) Product water quality

Based on the feed water quality as per design basis and the proposed operating strategy, all the product water quality objectives as per the directive from DWA (Annexure C) will not be met. The sulphate and electrical conductivity specification will not be met. It should be noted that this is based on the 95th percentile values that were used in the design.

If operated adequately, the product water qualities for Mn, Al and U should be below or very close to the specified standards.

The Government Directive from DWA as per **Annexure C** (**Table 3.4**) provides a different specification for the product water from that given in the BKS/Golder & Associates final specification document *(Report J01599-01 – Basis of Engineering Design, Final page 14, Table 10)*. **Table 3.4** below shows the differences of the product water specification used in the Government Directive and that of the final documentation from BKS/Golder:

Table 3.4: Comparison of Product Water 0bjectives and Expected Product Water Qualities

Parameter	Units	Government Directive (Annexure C)	BKS/Golder specification as per tender documentation	Expected product water quality from HDS Process (This study)*
pH	pH units	6.5 – 9.5	6 – 9	9.5
Conductivity (EC)	mS/m	350	Not specified	444 – 623
Sulphate	mg/ℓ as SO_4	2 500	<2 400	1 678 – 2 653
Aluminium	mg/ℓ as Al	<1	<1	< 1
Manganese	mg/ℓ as Mn	<10	<3	< 10
Iron	mg/ℓ as Fe	<1	<1	< 1
Uranium	mg/ ℓ as U	<50	<50	< 0.05

**Values based on 75th percentile of feed water quality. Values vary depending on basin. Study Report No. 5.4: "Treatment Technology Options"*

Each of the parameters will be discussed briefly:

- pH - There is a slight variation in the specification of the pH. The BKS/Golder process aims at controlling the final reactor at pH 8.5-9.0 for more efficient removal of Mn. A higher pH value of 9.5 would have been more advantageous for SO_4 and Mn removal.
- Conductivity - There is no specification for conductivity (EC) in the BKS/Golder documentation. It is unlikely that the process would be able to meet the conductivity specification from DWA, with the existing process and the feed as per design basis.
- Sulphate - There is a slight difference in sulphate specification between the Government Directive and the BKS/Golder specification. In both cases, the specification will most likely not be met if the process is simulated for the feed design basis (as per BKS/Golder & Associates' final specification: *Report J01599-01 – Basis of Engineering Design Final page 14, Table 3)*. In the proposed BKS/Golder process, no Mg is precipitated and Mg and Na keep SO_4 in solution which, in their absence, would have been associated with Ca and could have precipitated out at oversaturated conditions. This results in less precipitated $CaSO_4$ and higher SO_4 values in the product water. The expected SO_4 concentration in the product water is about 3 300-3 400 mg/ℓ.

- Aluminium - The values for Al in the final product correspond well and the process should be able to adequately remove Al to below this value. The expected Al value in the product water is 0.1-0.9 mg/ℓ.
- Manganese - The product specification for Mn in the Government Directive is very high and not adequate for release to the environment. It will result in clearly visible colouring of the water and also poses a health and toxicity risk. The product specification of the BKS/Golder final design is more adequate for release into the environment, although still marginally high. The expected quality from the proposed process, would be 0.5-3 mg/ℓ, depending mainly on the following critical factors:
  - Efficiency of aeration;
  - Operational pH of final reactor;
  - Adequate lime dosing;
  - Efficiency of Fe removal; and
  - Reaction time.
- Iron - Fe will in most cases be removed almost completely, prior to Mn. The specifications for Fe are the same for both cases. Fe will easily be removed by the proposed process to below the specification. The estimated product water quality will have a Fe concentration of 0.01 to 0.5 mg/ℓ.

d) Sludge handling

The sludge contains between 7% and 14% solids, which comprise primarily gypsum and metal precipitate. The sludge is highly scaling and the iron hydroxide means that it forms a difficult-to-handle sludge that is gelatinous. The handling of this sludge requires the following:

- Correct choice of process equipment;
- Adequate provision for maintenance and routine maintenance;
- Standby equipment, such as sludge pumps;
- Adequate choice of piping sizes and redundancy of sludge lines (redundancy included in contractor's design documentation);
- Control of suspended solids concentration in the recycle loop;
- Provision for unblocking pipelines; and
- Provision for flushing during non-production or emergency stop situations.

e) Aeration

As mentioned in the process description, aeration is required for oxidation of Fe (II) to Fe (III) in the neutralisation reactor where the pH is controlled above 6. The sufficiency and capacity of the aeration system is a process risk, if it is unable to deliver the required performance.

f) Removal of radio-nuclides (specifically Uranium)

The presence of radio-nuclides mainly uranium (U) in the feed water is a risk, especially if the water is to be used as potable water or discharged into the environment. The majority of these radio-nuclides will be present in the sludge produced by the HDS-Process as treatment of AMD by lime neutralisation and softening has shown to reduce uranium by 70 to 98% to less than 30 µg/ℓ. Usually, uranium precipitation by limestone or lime is enhanced by co-precipitation of gypsum. Thus, the higher the sulphate concentration in the feed water, the better the removal of U that can be expected by limestone/lime addition.

The presence of radio-nuclides should be determined for each precipitation step to determine hazard classification of the sludge for final disposal purposes.

3.1.6 Sludge Quality and Quantity from HDS Process

The quality and quantity of the sludge expected from the proposed HDS process for the TCTA feed water quality (95th percentiles) are summarised in **Table 3.5** and shows the following:

- All the basins' sludge from the HDS process will contain close to a third iron hydroxide sludge, which would be difficult to handle;
- A dewatering facility will reduce the waste stream significantly if the required capacity for storage is not available for the sludge waste stream; and
- It will be very difficult to re-use the sludge from the process as a by-product, because of the high metal content and non-uniform nature thereof.

The HDS process can be split into two stages, whereby an additional clarifier process step is incorporated between the neutralisation reactor and the gypsum crystallisation reactor with the lime being dosed only prior to the gypsum crystallisation reactor. This would result in two underflow/sludge lines from the two clarifiers. The first clarifier after the pre-neutralisation and neutralisation reactor after limestone and partial lime dosing can be controlled at a pH of about 6.5. It will produce a sludge consisting mainly of an iron and aluminium hydroxide metal sludge with partial gypsum precipitate.

Table 3.5: Expected Sludge Quantities and Composition

Precipitate [dry basis]	Units	Sludge Composition		
		Western Basin	Central Basin	Eastern Basin
$Fe(OH)_3$	%	32.5%	31.6%	38%
$Fe(OH)_2$	%	1.4%	3.7%	2%
$Al(OH)_3$	%	3.0%	0.1%	0%
$Mn(OH)_2$	%	9.2%	1.6%	1%
CaF_2	%	0.0%	0.0%	0%
$Ca_3(PO_4)_2$	%	0.0%	0.0%	0%
$Mg(OH)_2$	%	0.0%	0.0%	4%
$CaCO_3$	%	4.9%	4.4%	1%
$CaSO_4$	%	49.1%	58.6%	54%
Total Sludge [dry]	Tons/day	148.4	345.7	152.5
Total [if filter cake @ 35% moisture]	Tons/day	228.3	531.8	234.6
Total [if sludge @ 90% moisture]	Tons/day	1 484.2	3 457.0	1 525.0

The second clarifier after the gypsum crystallisation reactor will produce a sludge consisting mainly of gypsum and manganese hydroxide. Based on the fact that the manganese concentrations are relatively low for the Central and Eastern Basins; this two-stage precipitation process might be an alternative to consider for these two basins.

3.1.7 Suitability of the HDS Process as Pre-Treatment to Reverse Osmosis Desalination

Based on the feed water quality of the feed design basis (as per BKS/Golder & Associates final specification *Report J01599-01 – Basis of Engineering Design Final page 14 Table 3*) and the estimated efficiency of the proposed HDS process, further pre-treatment would be required in order to optimise the recovery and condition the water adequately to serve as feed for a RO desalination step.

Typically, the process will require metals such as Mn and Fe to be removed to levels of ~ 0.2 mg/ℓ. Mg needs to be removed to very low levels for optimum SO_4 precipitation. This could be achieved by operating the final reactor in the HDS process at a pH of 10.6-11. A pH adjustment, prior to ultra-filtration, will remove Al further to ~0.2 mg/ℓ. Ultra-filtration will remove all fines and carry-over from the softened clarified water from the HDS process. This will condition the water adequately for desalination in a RO plant. A recovery of 72-76% is possible. This will result in a concentrated brine stream where salts have been concentrated up by a factor of about 4. Other sparingly soluble salts have been ignored with regard to scaling, e.g. Ba, Sr, F, PO_4, Si, etc.

Another possibility would be to only remove the metals which are already at low concentrations (<3 mg/ℓ) by an oxidising agent at a pH of 9.5. A pH adjustment by acid and a similar process train, as described above, will then result in a RO recovery of 62 to 66%. This produces a concentrated brine stream where salts have been concentrated up by a factor of about 3.

Further overall process recovery can be achieved by treating the brine/waste/concentrate of the RO process by lime softening, resulting in gypsum precipitation. After softening the same process of pH adjustment with acid, ultra filtration and RO can be implemented. A series of RO trains with pre-treatment can be followed for an overall recovery of 90 to 98.5%+. Based on a rejection of 97.5 to 99%, a product water quality within DWA guidelines for drinking water (*SANS 241-1:2011*) can be expected with a TDS value of 80 to 250 mg/ℓ (depending on overall process recovery and final process configuration).

Thus, in short, the proposed HDS pre-treatment could easily be used / modified to act as a pre-treatment step for desalination as RO. Most process equipment of the proposed HDS process will be utilised.

3.2 The Short-Term Intervention

3.2.1 pH Neutralisation

Although the short-term pre-treatment has been designed, and is to be implemented, it provides only the initial step in AMD treatment, basically pH neutralisation and metals precipitation. The STI studies do not appear to have comprehensively considered the potential requirement to recover by-products from the AMD directly or from the neutralised sludge, or to re-use the sludge. Instead, the STI simply neutralises the AMD and generate a mixed sludge for disposal to tailings dams or open-pits, and may not present the most sustainable outcome to the handling of waste. The brief of the Feasibility Study requires that the STI be influenced as far as it is possible. However, the need for speedy implementation of the required emergency measures and the relative progress made with the roll-out of the STI in comparison to the Feasibility Study presents challenges. In addition, the outcomes of the Feasibility Study are also unclear at this stage. Thus, the possible influence that the Feasibility Study for a LTS might have on the STI is limited. Consideration has to be given to the respective objectives that the STI and LTS need to achieve, which are protection of the ECL and ensuring security of water supply in the Vaal River System. These objectives should not be compromised in an attempt to reconcile the STI and LTS.

It must be noted that there exists a risk that some of the STI infrastructure will not be compatible with the LTS to be proposed, and therefore might become redundant once the LTS infrastructure is commissioned.

The handling of the resultant sludge, and its potential for beneficiation and recovery of commercial by-products is directly related to the neutralisation agent used, as is the design basis for any subsequent potential desalination technology and handling of its resultant sludge and brine. The LTS would therefore consider the long-term sustainability of the short-term neutralisation approach, in relation to subsequent waste handling, re-use and disposal options, yet to be defined.

Whilst AMD neutralisation with lime, and aeration to precipitate metals and some of the sulphate as gypsum within the resultant sludge, is the conventional approach to AMD treatment, it does influence the subsequent technology selection for the required further salt removal/desalination, and does produce a mass of high volume, low density sludge for safe disposal and long-term environmental protection.

3.2.2 Metals and Radio-Nucleotide Removal

The key considerations in selecting an appropriate reagent for metal and radio-nucleotide precipitation include:

- Materials handling considerations, including road/rail transport, bulk storage, make up, and dosing;
- Classification of the sludge as a hazardous material, requiring special precautions in handling and personnel safety;
- Availability and reliability of the supply and cost of chemical reagents;

- Infrastructure and equipment investment cost of reagent handling, storage, make up, and use; and
- Treatment objectives.

The specific process arrangement for metals and radio-nucleotide removal is generally the same as for neutralisation – and is often in a lime/HDS configuration with additional chemical feed and control systems. The primary differences are the potential pre-treatment requirements, operation at an elevated pH, and the possible need to reduce the treated effluent pH with acid or carbon dioxide to meet effluent discharge pH requirements.

TCTA have indicated that they have had discussions with lime suppliers that indicate there is a commercial lime that has been developed that is superior to the conventional lime available in South Africa. It has apparently been suggested that the new lime could materially reduce the lime consumption rate, and subsequent sludge disposal volumes, but no details have been made available to date.

Alternative AMD desalination technologies such as electro-coagulation, ion-exchange and freeze desalination, that have apparently been presented as possible options, as well as multi-phase Reverse Osmosis, may not require the extent of pH neutralisation and metal oxidation and precipitation that the current HDS technology entails, since such technologies can potentially take the AMD directly, or with lesser pre-treatment than is required for the current HDS discharge quality limits.

3.2.3 HDS Disposal

The generation of sludge and waste from a range of treatment processes are discussed in DWA AMD FS 2012, Study Report No. 5.4: **"Treatment Technology Options"**. The options for long term management or disposal of sludge and other residues are discussed in DWA AMD FS 2012, Study Report No. 5.5: **"Residue Management of this Study"**.

The STI will neutralise the AMD, but will generate substantial quantities of iron rich, and potentially radio-nucleotide impacted, sludge, to be disposed of. Historically, the mine HDS plants (Grootvlei Mine) discharged the resultant sludge, along with their tailings to tailings dams, as a co-disposal approach.

The STI proposes to continue with the disposal of waste sludge to tailings dams, or open pits, or possibly as backfill into abandoned mine workings. This creates a number of potential problems in the long-term, which include:

i) The tailings dams, open pits and mine workings are owned by various mine groups. For the STI, agreements have been put in place for the management of waste sludge, but for the LTS there is no agreement that the tailings dams, open pits or abandoned mine workings can be used to receive the sludge, either by the facility owners or the authorities;

ii) The liability for the future closure and rehabilitation of the tailings dams, open pits and abandoned mine-workings that receive sludge has apparently not been determined;

iii) A cursory review of the legislation suggests relaxation of the legislation may be required to facilitate timeous authorisation for such waste disposal practices, which does not appear to have been accounted for in the Short-Term studies;

iv) The Short-Term studies do not appear to have determined the capacity of the available tailings dams, open pits or abandoned mine workings in the Central and Eastern basins to receive the projected sludge volumes and characteristics - The extent of the waste produced that is destined for disposal must be minimised as to not replace the current slimes dams with even larger brine and sludge deposits. However, in the Western Basin waste is already being co-disposed and heads of agreement have been reached with ERGO. The disposal is within the existing authorisation.

v) The Short-Term studies do not appear to have confirmed the engineering requirements to allow the tailings dams, open pits or abandoned mine workings to receive the projected sludge volumes and characteristics;

vi) The Short-Term studies do not appear to have demonstrated that the sludge can be stabilised/managed to allow future disposal to tailings dams, open pits or abandoned mine workings, without undue environmental impact;

vii) The long-term environmental liability for such sludge disposal to existing tailings dams, open pits or abandoned mine workings has not been determined in the Short-Term project;

viii) The need for, the location of, and design basis for dedicated hazardous waste storage/disposal facilities to receive the sludge will have to be considered in the LTS;

ix) Heads of agreement have been reached to dispose waste sludge to existing landfills or other waste disposal facilities, has not been determined in the Short-Term project;

x) The opportunity to beneficiate the waste sludge has not been determined in the STI.

xi) Commercial arrangements for blending, conveying and storage of the wastes has not been addressed in the STI;

xii) The return water from the TSFs after the tailings deposition has ceased has not been addressed in the STI;

xiii) Where the management of sludge will have an impact on water resources, a water use license will be required and will have to be addressed.

xiv) Permitting and licensing of the TSFs, including monitoring and operation towards closure, has not been addressed in the STI; and

xv) Delayed issuance of a closure permit to the TSF owner – this can be costly in the long run and can incur substantial costs.

All of the above potential problems, including others such as socio-economic and environmental challenges, should be addressed in the EIA which will cover both the STI and the LTS.

TCTA has confirmed that sludge dewatering, either mechanically or physically, will not be required in the STI;

Risks associated with the waste sludge management and disposal infrastructure that appear to have been addressed in the STI, include:

- Eventual classification of the waste sludge – hazardous or general;
- Environmental and licensing constraints and delays – pipelines and disposal areas;
- Liner requirements;
- Blockage and reserve capacity;
- Duty and standby pumps;
- Capacity of the receiving facility (pit, shaft, TSF); and
- Return water system security and operation, and electrical supply to these, after the TSF owners no longer use these facilities,

HDS has internationally been placed in abandoned deep mines or in pits dug on surface mines, to take advantage of its excess alkalinity (due to unconsumed hydrated lime), but this is only appropriate if the environment, that the sludge is being placed into, is not acidic. If the sludge is exposed to sufficiently acidic water, the sludge can re-dissolve, neutralising the pH somewhat, but increasing the dissolved metal content.

3.3 Conclusions

In assessing the actions recommended for the STI, it was determined that the STI can only be viewed as a short term intervention with the aim of reducing the environmental impact.

The STI investigated only proven technology, and hence the HDS Process was selected for the treatment of the AMD. This is the logical decision, taking into account the limited time that was allowed for the implementation of the project.

In assessing the design parameters of the STI, the following was noticed:

(a) The design was based on the 95th Percentile of the available data. This is a conservative approach as only 5% of the values will be worse than the accepted levels. It can be expected that the real values will be between the 50th and the 75th Percentile.

(b) The retention time proposed in some of the reactor compartments are believed to be very short. This could lead to the quality envisaged by the designers not being achieved. Specifically the SO_4 concentration is believed to be exceeded.

(c) In exceeding the SO_4 concentration, the limits set for the EC will also not be met. It is thus evident that the STI can only be viewed as a temporary solution. The LTI is required to be implemented with great urgency.

The management of the sludge proposed for the STI has severe long-term deficiencies with regards to the storage capacity. The storage facilities identified in the Western Basin for the sludge disposal generated by the STI only has enough capacity for another 3 – 4 years; therefore, this will be one of the pressing issues that must be addressed by the LTS. The TCTA has stated that in the Central and Eastern Basins provision has been made for the disposal of sludge from the STI for a period of 30 years

As per the TCTA, binding agreements have been made with the owners of the slimes dumps where the sludge will be deposited with the slimes produced by the gold recovery processes.

In this regards, it is important that issues such as the liability for the sludge being deposited on the slimes dams are specified clearly, and that the parties accept their respective responsibilities.

The issues regarding the management of the Uranium in the AMD are not clearly addressed in the STI. The LTS will have to find an acceptable solution to this problem.

Compliance with the Directive issued to TCTA, which had the objective of stopping decant in the Western Basin and protecting the ECLs in the other two basins, will result in a high sulphate load in the Vaal River System. Reducing the salt-loading to acceptable levels to ensure security of water supply of the Vaal River System is one of the main objectives of the LTS.

4 ENVIRONMENTAL ASPECTS

4.1 Introduction

Although AMD is essentially an environmental problem, the remediation thereof through engineering measures will cause its own suite of environmental impacts in the Short- and Long-Term Solutions, which should be identified and assessed. To this end, the brief included the evaluation of the long term environmental suitability of the STI. This step is especially important since exemption and authorisation have been granted for the STI in terms of the National Environment Management Act 107 of 1998 (NEMA 107: 1998) GNR.543 (refer to Annexure D).

4.2 Objectives

This evaluation was done on a high level, and based on information from the *Due Diligence Report* for the short-term, as well as typical provincial databases, such as *Gauteng's Conservation Plan (version 3)*. It was done in order to derive possible areas of high environmental sensitivity and subsequent fatal flaws with the STI. No site visits or detailed investigations, other than desktop information, were used.

A more detailed assessment of the environmental impacts of the STI will be conducted as part of the combined EIA process for the STI and LTS.

4.3 Evaluation of the Short-Term Interventions

One of the factors that must be considered in order to evaluate options for the LTS is that the STI is not sustainable over the long term with regard to environmental and surface water quality. The environmental authorisation granted for the STI acknowledges this. This section considers the suitability of the following project components of the STI for each basin:

- Abstraction point;
- AMD pipeline to treatment plant;
- Position of treatment plant;
- Neutralised water pipeline to surface water discharge point; and
- Waste sludge pipeline to disposal point.
- Sludge storage / disposal facility

Environmental aspects such as environmental risk owing to pipe failure, long term liability, and receiving environment (greenfields vs. brownfields), were considered. More detail on the evaluation can be found in **Appendix E**. The requirements of the receiving watercourses in terms of the Reserve and Resource water Quality Objectives (RWQO) are not considered here but are considered in detail in the DWA AMD FS 2012, Study Report No. 5.3: **"Options for Use or Discharge of Water"**.

5 IMPLICATIONS FOR PROCUREMENT OF THE LTS

The procurement of the solution for the AMD in each the three mining basins will have to be carried out in two phases: The STI and the LTS. This will either place constraints on the possible options available for the LTS or have cost implications if any of the STI works do not form part of the LTS. The economics of the alternatives will have to be assessed.

If the procurement strategy for the LTS is that Government will fund the capital required and sequentially procure the design, construction and be responsible for the operation and maintenance, then DWA will take on the technical and financial risk of both the STI and the LTS.

In the case of the LTS being a Design, Build, Operate, Maintain (DBOM), or Public Private Partnership (PPP) solution, then the Private Party will be expected to take responsibility for the operation and maintenance of the STI. The Private Party, taking over existing operational infrastructure will be constrained in the technical solution that it can offer. The level of risk that Government will be able to transfer to the Private Party will be reduced.

The Private Party will have to take over the abstraction and treatment designs and the equipment selected and installed the STI. The Private Party in a PPP or DBOM will only be able to select the desalination technology downstream of the STI unless they decide to abandon parts of the STI, because they can offer a more economic “greenfields” solution.

It is likely that the Private Party will take over these risks, provided that Government provides an indemnity against the supply of raw water, the connectivity of the underground structures and that there are some guarantees on the equipment selected, installed, operated and maintained by TCTA and DWA before the LTS contracts are let. While National Treasury are strongly against providing indemnities to the Private Sector in PPPs, there is little chance that a Private Party will take over someone else’s design and infrastructure installation, with zero risk premium or installed mitigation costs, especially where the infrastructure is difficult to inspect and assess.

For more information on the STI implications for the LTS refer to **Appendix F**.

REFERENCES

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TCTA Due Diligence Report from BKS and Golder & Associates: Speculation Document "Report J01599-01 – Basis of Engineering Design, Final".

Gauteng's Conservation Plan (version 3) – Typical provincial databases.

Digby Wells Environmental Consultants. A more detailed assessment of the environmental impacts of the STI is currently conducted as part of the NEMA Section.

Annexure A
Directive to TCTA for Emergency Works

MINISTER
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REPUBLIC OF SOUTH AFRICA

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Ref.: AMD-DIR-TCTA-01.03.2011

Dr Snowy Khoza
Chairperson
Trans-Caledon Tunnel Authority
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Dear Dr Khoza

EMERGENCY WORKS WATER MANAGEMENT ON THE WITWATERSRAND GOLD FIELDS WITH SPECIAL EMPHASIS ON ACID MINE DRAINAGE: DIRECTIVE IN TERMS OF THE NATIONAL WATER ACT, 1998 (ACT 36 OF 1998)

Following concerns about acid mine drainage (AMD) impacts on the Witwatersrand gold fields, Cabinet appointed an Inter-Ministerial-Committee (IMC) to address the serious challenges posed by the AMD. A Technical Committee, tasked by the IMC and co-chaired by the Director-General of the Department of Mineral Resources and the acting Director-General of the Department of Water Affairs (DWA), subsequently appointed a Team of Experts who presented a final draft report to Cabinet on 9 February.

The following recommendations, as emergency works, in the report (attached as **Appendix A**) were approved by the IMC and Cabinet for implementation:

I. Installation of pumps to extract water from the mines to on-site treatment plants
II. Construction of an on-site water treatment plant in each Basin with the option of refurbishing and upgrading the existing ones owned by the mines
III. Installation of infrastructure to convey treated water to nearby water courses
IV. Operation of the pump stations and treatment works

I hereby direct the TCTA in terms of section 103 (2) of the National Water Act, 1998 (Act 36 of 1998) to undertake the emergency works (hereafter referred to as the Project) subject to the following conditions:

1. Funding for the Project shall be via funds allocated by the National Treasury and made available to TCTA via the DWA. Procedures to govern the disbursements of funds between the TCTA and the DWA shall be incorporated into an Implementation Agreement.
2. Relevant current best practices, and where applicable, international standards, shall be applied for the design, construction and supervision of the Project.
3. The TCTA will lead the process of obtaining the environment al authorisations of the works from the Department of Environmental Affairs (DEA); the TCTA shall ensure that all the steps are taken to ensure compliance with environmental legislation.
4. The TCTA shall liaise with the DWA regarding the longer term AMD management objectives and ensure compatibility of the Project with future application of AMD.

5. An Implementing Agreement for the Project must be concluded within three (3) months of the date of the directive between the DWA and the TCTA setting out clear lines of responsibility and accountability.
6. The Project must be implemented in the most efficient manner with due regards to cost, timing and reliability.
7. Available DWA and TCTA organisational resources shall be pooled in a manner that will build capacity for the management, development and delivery of the Project.
8. The TCTA shall establish institutional arrangements and process to ensure meaningful participation by all the relevant stakeholders of the project.
9. All Projects implementation actions shall comply with the applicable South African legislation and codes of conduct.
10. The TCTA shall include the facilitation of the best model, which shall be proposed to (the DWA) and decided upon by the DWA for the operations of the pumping stations and the treatment works.
11. The TCTA's communication strategy on the Project needs to reflect the representative roles and responsibilities of the DWA with the relevant stakeholders.
12. Land rights for the Project shall be acquired in accordance with South African statutes.
13. Progress reports on the Project shall be submitted to me every month, as well as on ad hoc issues that require my attention and intervention.
14. After completion of the project, the DWA shall assume responsibility for the operations and maintenance.
15. I may direct the TCTA to undertake further works.

In terms of section 64(1) of the said National Water Act, 1998, I hereby authorise the TCTA to expropriate property required to implement the Project.

I wish you success in executing this important assignment.

Yours sincerely

MRS B E E MOLEWA MP
MINISTER OF WATER AND ENVIRONMENTAL AFFAIRS
DATE: 06·04·2011

Cc – CEO: Trans-Caledon Tunnel Authority

Annexure B
Directive to TCTA for Western Basin Emergency Works Sludge Disposal

water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Gauteng Regional Office
15th Floor, Bothongo Plaza East, 285 Schoeman Street, Pretoria

Telephone	012 392 1415	Private Bag X995	Enquiries	Mr B. Govender
e-mail	GovenderB@dwa.gov.za	Pretoria		
Facsimile	012 392 1359	0001	Reference	16/2/7/C231/G003

The Chief Executive Officer
Mr James Ndlovu
The Trans-Caledon Authority
PO Box 10335
CENTURION
0046

Dear Mr Ndlovu

DIRECTIVE IN TERMS OF SECTIONS 19 AND 20 OF THE NATIONAL WATER ACT, 1998 (ACT 36 OF 1998) [NWA] TO THE TRANS-CALEDON TUNNEL AUTHORITY (TCTA)

AUTHORISATION FOR THE DISPOSAL OF SLUDGE DERIVED DURING THE EMERGENCY WORKS (IMMEDIATE SOLUTION) TO ADDRESS ACID MINE DRAINAGE (AMD) IN THE WESTERN BASIN INTO THE WEST WITS PIT (WWP), KRUGERSDORP

1. BACKGROUND

1.1 A directive from the Minister of Water and Environmental Affairs dated 06 April 2011 directed the TCTA to undertake certain emergency works for the management of AMD in the Witwatersrand mining basins.

1.2 In accordance with the directive, the TCTA submitted a Report titled "Formulation of Western Basin AMD Immediate Mitigation Measures" (Report No. J01599/02 of July 2011). The Report identified an immediate solution to address AMD in the Western Basin.

1.3 A letter dated 02 August 2011 from the Department of Water Affairs (DWA) authorised the TCTA to implement the immediate solution.

2. REASONS FOR THE DIRECTIVE

2.1 The immediate solution, when commissioned and operated, will produce large volumes of sludge formed by the reaction between mine water (AMD) and neutralisation agents ($CaOH_2$ and / or $CaCO_3$). Chemically, the sludge will be composed of $CaSO_4$-heavy metal co-precipitate and will require disposal into a suitable facility. The TCTA's Report in (1.2) has identified the WWP as a possible site for disposal of the sludge. In terms of the NWA, the DWA must ensure certain regulatory specifications are in place to authorise the disposal of the sludge.

3. DIRECTIVE

I, Hendrik Albertus Smit, in my capacity as Regional Head: Gauteng, in the Department of Water Affairs and acting under authority of the power delegated to me by the Minister of Water and Environmental Affairs in terms of Section 63 of the NWA, after taking into account the representations made by the TCTA and the Report referred to in (1.2), hereby direct the TCTA in terms of Sections 19 and 20 of the NWA, subject to the terms and conditions set out below, to perform the following:

3.1 Conduct sludge deposition into the WWP in accordance with the following conditions:

i. Sludge must be co-disposed with processed tailings generated by the Mogale Gold Pty Ltd operation. The TCTA must inform the DWA in writing of the existing preventative and mitigation measures for hydrological, chemical, microbiological or radioactive processes that result in the contamination of the groundwater and surface water resources.

ii. A sludge-tailings co-disposal method must be developed by an accredited engineer and submitted to the DWA for approval within ninety (90) days from date of issuance of this Directive.

iii. Waste classification tests must be conducted on the sludge including appropriate studies to establish the physico-chemical properties of the sludge and its suitability for co-disposal with tailings into the WWP. These studies include, but are not limited to chemical and physical composition, potential to generate acid and / or leach heavy metals, stability, behaviour under varying conditions of hydration, resistance to natural elements and panning (crusting) tendency of the sludge-tailings compound. The chemical tests should be performed to the same standards as those performed in the licensing of the disposal of tailings to the WWP and should include, as a minimum, paste pH, acid-base accounting, synthetic acid rain leaching and toxicity characteristic leach procedure (TCLP), with all tests to be performed on the tailings, sludge and the likely tailings-sludge mixture.

iv. An agreement for co-disposal of sludge and tailings into the WWP must be reached with Mogale Gold Pty Ltd and the Mogale City Local Municipality within ninety (90) days from date of issuance of this Directive.

v. The Fraser Alexander Report titled "West Wits Pit: South Pit Filling *Modus Operandi*", dated September 2009, under reference Addendum to FA/BR/021/2009 which stipulates environmentally-optimal tailings deposition methods to be employed to manage tailings deposition and the pool in the WWP.

3.2 Notwithstanding the above, specific attention is drawn to the following:

i. Only sludge derived from the emergency works and tailings processed through the Mogale Gold Pty Ltd operation may be co-disposed into the WWP.

ii. The co-deposition of tailings and sludge may only continue until the surrounding natural ground level is attained and is subject to proof that disposal has not caused deleterious environmental consequences.

iii. In conjunction with (3.1 iv), the TCTA must finalise an agreement with Mogale Gold Pty Ltd on the apportionment of obligations and liabilities with regard to closure of the WWP and rehabilitation thereof.

iv. The TCTA must inform the DWA of current measures applied to prevent ingress of the sludge-tailings deposit into the underground mine void including the management/remediation of sinkholes and subsidences that may be incurred during sludge-tailings co-deposition.

v. The TCTA must inform the DWA of contingency measures that will be put in place should sludge-tailing co-deposits decant or if there is any evidence of groundwater pollution.

3.3 Sludge-tailings co-disposal methods must ensure that any water present in the mixture is adequately de-watered and that return water volumes collecting in the WWP are kept to a minimum. Return water must be pooled to a suitable region of the WWP and pumping infrastructure must be commissioned to ensure pooled water can be extracted for use in the emergency works and / or the Mogale Gold Pty Ltd processes.

3.4 The TCTA must reach an agreement with Mogale Gold Pty Ltd to utilise existing boreholes on the perimeter of the WWP and / or establish suitable boreholes for the implementation of a groundwater monitoring programme that will analyse for the following:

i. pH;
ii. electrical conductivity;
iii. $S0_4^{2-}$;
iv. suspended solids;
v. total dissolved solids and;
vi. Fe, U, Na, Mg, Cl, Ca, Al and Mn.

For two (2) years from commencement of sludge disposal, analyses must be conducted on a quarterly basis. Thereafter, groundwater monitoring shall be conducted bi-annually;

3.5 Any water pooled in the WWP, together with water samples extracted from the 8 Shaft, must be analysed as per variables and frequency outlined in (3.4);

3.6 Record the date, time and monitoring point in respect of each sample taken together with the results of the analyses;

3.7 Monitoring points shall not be changed prior to notification and written approval from the Regional Head;

3.8 Complete all analysis of samples in accordance with methods prescribed by and obtainable from the South African Bureau of Standards (SABS), in terms of the Standards Act, 2008 (Act 8 of 2008);

3.9 Ensure that methods of analysis are not changed without prior notification of and written approval from the Regional Head;

3.10 Submit an updated water balance and calculated loads of waste emanating from the activities within ninety (90) days from date of issuance of this Directive;

3.11 Report in writing, on a quarterly basis, all sampling results to the Regional Head;

3.12 The TCTA must inform the DWA of the measures taken by Mogale Gold Pty Ltd to prevent water containing waste or any substance which causes or is likely to cause pollution of water resources from entering any water resource either by natural flow or by seepage, and retain or collect such substance or water for use, re-use, evaporation or for purification and disposal;

3.13 The TCTA must inform the DWA of the measures taken by Mogale Gold Pty Ltd for the appropriate management of storm water in the vicinity of the WWP;

3.14 Install flow measuring systems on the emergency works plant to account for sludge and water volumes;

3.15 Check and maintain all pipelines on a daily basis;

3.16 Ensure that the operator of the treatment plant maintains accurate and up-to-date records of all system malfunctions resulting in non-compliance with the requirements of this Directive. These records must be made available for inspection by the Regional Head upon request. Such malfunctions must be tabulated under the following headings with a full explanation of all the contributory circumstances:

- i. operating errors;
- ii. mechanical and structural failures (including design, installation or maintenance);
- iii. environmental factors (e.g. flood);
- iv. loss of supply services (e.g. power failure) and;
- v. other causes.

3.17 Ensure that the operator of the treatment plant notifies the Regional Head within 24 hours of the occurrence or potential occurrence of any incident which has the potential to cause, or has caused water pollution, pollution of the environment, health risks or which is a contravention of the conditions of the Directive;

3.18 The TCTA must reach an agreement with Mogale Gold Pty Ltd to introduce radiation control monitoring and any radiation control measures that may be required in accordance with the specifications of the National Nuclear Regulator (NNR);

3.19 The TCTA must reach an agreement with Mogale Gold Pty Ltd to assess the radiological risk to affected water bodies (including both surface and groundwater) via a programme of analysis for radionuclides in accordance with a radiological risk assessment procedure to be submitted to the NNR for approval within sixty (60) days and approved by the NNR.

4. Non-compliance to the conditions of this Directive should immediately be reported to the Regional Head in writing. Such a report should include measures to be instituted towards correcting non-compliance.

5. Should the TCTA fail to comply, or comply inadequately with any term of this Directive, the DWA may take measures it considers necessary to remedy the situation, including but not limited to:

- i. Criminal proceedings against any of the parties in terms of Section 151 of the Act, and;
- ii. Taking the measures itself and recovering the costs thereof from any of the parties, in terms of Section 19(4) of the Act.

6. In terms of Section 124 of the NWA, the DWA has the power to inspect the land on which any activity in terms of this Directive is carried out.

7. This Directive will remain in force and becomes effective from date of signature until it is superseded by a Section 21 water use licence issued by the DWA in terms of Section 41 of the NWA.

8. This Directive is subject to the special terms and conditions that should any of the material terms and conditions of the Directive not be implemented or is breached by the TCTA, the DWA reserves its right to withdraw this Directive.

9. Your attention is drawn to the fact that you may lodge an appeal against this Directive to the Water Tribunal in terms of Section 148(1)(a) of the NWA. Contact details of the Water Tribunal are:

Postal Address:
The Registrar
Water Tribunal
Private Bag x316
Pretoria, 0001

Physical Address:
Room 344
Waterbron Building
191 Schoeman Street
Pretoria, 0001

Telephone	012 336 8297
Facsimile	012 336 8666

10. Please note that even though a party may appeal against this Directive to the Water Tribunal, such an appeal in terms of Section 148(2) of the NWA does not suspend the Directive, pending the outcome of the Directive.

SIGNED AT PRETORIA ON THE 07 **DAY OF** November **2011.**

REGIONAL HEAD: GAUTENG

Annexure C
Directive to TCTA for Western Basin Emergency Works Disposal of Treated AMD

water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Gauteng Regional Office
15th Floor, Bothongo Plaza East, 285 Schoeman Street, Pretoria

Telephone	012 392 1415	Private Bag X995	Enquiries	Mr B. Govender
e-mail	GovenderB@dwa.gov.za	Pretoria		
Facsimile	012 392 1359	0001	Reference	16/2/7/C231/G003

The Chief Executive Officer
Mr James Ndlovu
The Trans-Caledon Authority
PO Box 10335
CENTURION
0046

Dear Mr Ndlovu

DIRECTIVE IN TERMS OF SECTIONS 19 AND 20 OF THE NATIONAL WATER ACT, 1998 (ACT 36 OF 1998) [NWA] TO THE TRANS-CALEDON TUNNEL AUTHORITY (TCTA)

AUTHORISATION FOR THE DISPOSAL OF TREATED MINE WATER DERIVED DURING THE EMERGENCY WORKS (IMMEDIATE SOLUTION) TO ADDRESS ACID MINE DRAINAGE (AMD) IN THE WESTERN BASIN INTO THE TWEELOPIES (EAST) SPRUIT, KRUGERSDORP

1. BACKGROUND

1.1 A directive from the Minister of Water and Environmental Affairs dated 06 April 2011 directed the TCTA to undertake certain emergency works for the management of AMD in the Witwatersrand mining basins.

1.2 In accordance with the directive, the TCTA submitted a Report titled "Formulation of Western Basin AMD Immediate Mitigation Measures" (Report No. J01599/02 of July 2011). The Report identified an immediate solution to address AMD in the Western Basin.

1.3 A letter dated 02 August 2011 from the Department of Water Affairs (DWA) authorised the TCTA to implement the immediate solution.

2. REASONS FOR THE DIRECTIVE

2.1 The immediate solution, when commissioned and operated, will produce approximately 27 – 32 ML / day of treated mine water. The Report in (1.2) has identified the Tweelopies (East) Spruit as a possible site for discharge of the treated mine water. In terms of the NWA, the DWA must ensure certain regulatory specifications are in place to authorise the discharge.

3. DIRECTIVE

I, Hendrik Albertus Smit, in my capacity as Regional Head: Gauteng, in the Department of Water Affairs and acting under authority of the power delegated to me by the Minister of Water and Environmental Affairs in terms of Section 63 of the NWA, after taking into account the representations made by the TCTA and the Report referred to in (1.2), hereby direct the TCTA in terms of Sections 19 and 20 of the NWA, subject to the terms and conditions set out below, to perform the following:

3.1 The TCTA must reach an agreement with Rand Uranium Pty Ltd to pump and treat the Western Basin mine void water to the conditions stipulated in (3.2) prior to discharging the treated water into the Tweelopies (East) Spruit at a point above the Krugersdorp Game Reserve;

3.2 The discharge of treated mine water to the Tweelopies (East) Spruit shall at all times not exceed the values stipulated in Table 1;

Table 1

Variable (Symbol) (Unit)	Value
pH	6.5 – 9.5
Conductivity (EC) (mS/m)	350
Sulphate ($S0_4^{2-}$) (mg/L)*	2500
Aluminium (Al) (mg/L)*	<1
Manganese (Mn) (mg/L)*	<10
Iron (Fe) (mg/L)*	<1
Uranium (U) (µg/L)*	<50

*dissolved

3.3 The TCTA must reach an agreement with Rand Uranium Pty Ltd to implement a surface water and groundwater monitoring programme as detailed in (3.4) and (3.5) to determine the extent of the impact from the point of discharge into the Tweelopies (East) Spruit;

3.4 Sample and analyse surface water at the points stipulated in Table 2;

Table 2

Sampling point	Frequency	Variables
Extraction from the mine shaft	Daily (mine laboratory)	Flow, pH, EC, TDS
	Weekly (accredited independent laboratory)	Flow, pH, EC, TDS $S0_4^{2-}$, Fe, U, Al, Mn, Pb,
Discharge of treated water into the Tweelopies (East) Spruit (point of continuous monitoring)	Daily (mine laboratory)	Flow, pH, EC, TDS
	Weekly (accredited independent laboratory)	Flow, pH, EC, TDS $S0_4^{2-}$, Fe, U, Al, Mn, Pb,
Upstream of the Krugersdorp Game Reserve (R24 road culvert)	Weekly (accredited independent laboratory)	Flow, pH, EC, TDS $S0_4^{2-}$, Fe, U, Al, Mn, Pb
Downstream of the Krugersdorp Game Reserve (Aviary Dam)	Weekly (accredited independent laboratory)	Flow, pH, EC, TDS $S0_4^{2-}$, Fe, U, Al, Mn, Pb
Tweelopies (East) Spruit: Upstream of the confluence of the Tweelopies (East) and Tweelopies (West) Spruits (Brick Dam)	Weekly (accredited independent laboratory)	Flow, pH, EC, TDS $S0_4^{2-}$, Fe, U, Al, Mn, Pb

Table 2 continued

Sampling point	Frequency	Variables
Riet Spruit: Downstream of the confluence of the Tweelopies (East) and Tweelopies (West) Spruits (Morester Camp)	Weekly (accredited independent laboratory)	Flow, pH, EC, TDS SO_4^{2-}, Fe, U, Al, Mn, Pb

3.5 Conduct groundwater monitoring at sites representative of the surface water sampling points stipulated in (3.4). The variables analysed for in groundwater must be the same as for surface water with the exception of flow.
For two (2) years from commencement of the discharge, analyses must be conducted on a quarterly basis. Thereafter, groundwater monitoring shall be conducted bi-annually;

3.6 Submit the groundwater monitoring programme to the Regional Head within three (3) months from date of receipt of this Directive for approval;

3.7 Record the date, time and monitoring point in respect of each sample taken together with the results of the analyses;

3.8 Complete all analysis of samples in accordance with methods prescribed by and obtainable from the South African Bureau of Standards (SABS), in terms of the Standards Act, 2008 (Act 8 of 2008).

3.9 Ensure that methods of analysis referred to in (3.8) are not changed without prior notification of and written approval from the Regional Head;

3.10 Report in writing, on a monthly basis, all sampling results to the Regional Head.

3.11 Submit an updated water balance and calculated loads of waste emanating from this activity within three (3) months from date of receipt of this Directive;

3.12 Maintain accurate and up-to-date records of all system malfunctions resulting in non-compliance with the requirements of this Directive. These records must be made available for inspection by the Regional Head upon request. Such malfunctions must be tabulated under the following headings with a full explanation of all the contributory circumstances:

i. operating errors;
ii. mechanical failures (including design, installation or maintenance);
iii. environmental factors (e.g. flood);
iv. loss of supply services (e.g. power failure); and
v. other causes.

3.13 Notify the Regional Head of the occurrence or potential occurrence of any incident which has the potential to cause, or has caused water pollution, pollution of the environment, health risks or which is a contravention of the conditions of this Directive;

3.14 The TCTA must reach an agreement with Rand Uranium Pty Ltd to introduce radiation control monitoring and any radiation control measures that may be required in accordance with the specifications of the National Nuclear Regulator (NNR);

3.15 Report any non-compliance to the conditions of this Directive immediately to the Regional Head in writing. Such a report must include measures to be instituted towards correcting non-compliance;

3.16 Apply for a water use licence in terms of Section 21 of the NWA for all water uses contemplated in this Directive within 90 (ninety) days from date of receipt of this Directive.

4. Non-compliance to the conditions of this Directive should immediately be reported to the Regional Head in writing. Such a report should include measures to be instituted towards correcting non-compliance.

5. Should the TCTA fail to comply, or comply inadequately with any term of this Directive, the DWA may take measures it considers necessary to remedy the situation, including but not limited to:

i. Criminal proceedings against any of the parties in terms of Section 151 of the NWA and;

ii. Taking the measures itself and recovering the costs thereof from any of the parties, in terms of Section 19(4) of the NWA.

6. In terms of Section 124 of the NWA, the DWA has the power to inspect the land on which any activity in terms of this Directive is carried out.

7. This Directive will remain in force and becomes effective from date of signature until it is superseded by a Section 21 water use licence issued by the DWA in terms of Section 41 of the NWA.

8. This Directive is subject to the special terms and conditions that should any of the material terms and conditions of the Directive not be implemented or is breached by the TCTA, the DWA reserves the right to withdraw this Directive.

9. Your attention is drawn to the fact that you may lodge an appeal against this Directive to the Water Tribunal in terms of Section 148(1)(a) of the NWA. Contact details of the Water Tribunal are:

Postal Address:
The Registrar
Water Tribunal
Private Bag X316
PRETORIA, 0001

Physical Address:
Room 344
Waterbron Building
191 Schoeman Street
PRETORIA, 0001

Telephone 012 336 8297
Facsimile 012 336 8666

10. Please note that even though a party may appeal against this Directive to the Water Tribunal, such an appeal in terms of Section 148(2) of the NWA does not suspend the Directive, pending the outcome of the Directive.

SIGNED AT PRETORIA ON THE 07 **DAY OF** November **2011.**

REGIONAL HEAD: GAUTENG

Annexure D
Granting of Exemption from EIA and Environmental Authorisation for STI

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Private Bag X 447· PRETORIA · 0001· Fedsure Building · 315 Pretorius Street · PRETORIA
Tel (+ 27 12) 310 3911 · Fax (+ 2712) 322 2682

NEAS Reference: DEA/EIA/0000498/2011
DEA Reference: 12/12/20/2403
Enquiries: Masina Litsoane
Telephone: 012-395-1778 **Fax:** 012-320-7539 **E-mail:** MLitsoane@environment.gov.za

Mr. Bashan Govender
Deparment of Water Affairs
Private Bag X995
PRETORIA
0001

Fax no: 012-392-1359

PER FACSIMILE / MAIL

Dear Mr Bashan

APPLICATION FOR ENVIRONMENTAL AUTHORISATION IN TERMS OF THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998: GN R.543: IMMEDIATE AND SHORT TERM INTERVENTIONS FOR THE TREATMENT OF ACID MINE DRAINAGE IN THE WESTERN, CENTRAL AND EASTERN BASINSOF THE WITWATERSRAND GOLD FIELDS, GAUTENG PROVINCE

With reference to the above application, please be advised that the Department has decided to grant exemption and authorisation. The environmental authorisation (EA) and reasons for the decision are attached herewith.

In terms of regulation 10(2) of the Environmental Impact Assessment Regulations, 2010 (the Regulations), you are instructed to notify all registered interested and affected parties, in writing and within 12 (twelve) days of the date of the EA, of the Department's decision in respect of your application as well as the provisions regarding the submission of appeals that are contained in the Regulations.

Your attention is drawn to Chapter 7 of the Regulations, which prescribes the appeal procedure to be followed. This procedure is summarised in the attached document. Kindly include a copy of this document with the letter of notification to interested and affected parties.

Should the applicant or any other party wish to appeal any aspect of the decision a notice of intention to appeal must be lodged by all prospective appellants with the Minister, within 20 days of the date of the EA, by means of one of the following methods:

By facsimile:	012 320 7561;
By post:	Private Bag X447, Pretoria, 0001; or
By hand:	2nd Floor, Fedsure Building, North Tower, Cnr. Lilian Ngoyi (Van der Walt) and Pretorius Streets, Pretoria.

If the applicant wishes to lodge an appeal, it must also serve a copy of the notice of intention to appeal on all registered interested and affected parties as well as a notice indicating where, and for what period, the appeal submission will be available for inspection, should you intend to submit an appeal.

Please include the Department *(Attention: Director: Integrated Environmental Authorisations)* in the list of interested and affected parties, notified through your notification letter to interested and affected parties, for record purposes.

Appeals must be submitted in writing to:

Mr T Zwane, Senior Legal Administration Officer (Appeals), of this Department at the above mentioned addresses or fax number. Mr Zwane can also be contacted at:

Tel: 012-310-3929
Email: AppealsDirectorate@environment.gov.za

Please note that the Minister may, on receipt of appeals against the authorisation or conditions thereof suspend the authorisation pending the outcome of the appeals procedure.

Yours sincerely

Mr Mark Gordon
Chief Director: Integrated Environmental Authorisations
Department of Environmental Affairs
Date: 07/01/2013

CC:	Mr S Horak	Digby Wells	Tel: 011-789-9495	Fax: 011-789-9498
	Mr H Nkosi	Ekurhuleni Metropolitan Municipality	Tel: 011-999-3316	Fax: 086-506-8177
	Ms L Molefe	City of Johannesburg	Tel: 011-587-4238	Fax: 011-587-4228
	Mr M Mokoena	Mogale City Local Municipality	Tel: 011-951-2101	Fax: 011-660-1507
	Mr T Zwane	Appeals Authority (DEA)	Tel: 012-310-3929	Fax: 012-320-7561
	Mr S Malaza	Compliance Monitoring (DEA)	Tel: 012-310-3397	Fax: 012-320-5744

APPEALS PROCEDURE IN TERMS OF CHAPTER 7 OF THE NEMA EIA REGULATIONS, 2010 (THE REGULATIONS) AS PER GN R. 543 OF 2010 TO BE FOLLOWED BY THE APPLICANT AND INTERESTED AND AFFECTED PARTIES UPON RECEIPT OF NOTIFICATION OF AN ENVIRONMENTAL AUTHORISATION (EA)

APPLICANT	INTERESTED AND AFFECTED PARTIES (IAPs)
1. Receive EA from the relevant Competent Authority (the Department of Environmental Affairs [DEA]).	1. Receive EA from Applicant/Consultant.
2. Within 12 days of date of the EA notify all IAPs of the EA and draw their attention to their right to appeal against the EA in terms of Chapter 7 of the Regulations.	2. N/A.
3. If you want to appeal against the EA, submit a notice of intention to appeal within 20 days of the date of the EA with the Minister of Water and Environmental Affairs (the Minister).	3. If you want to appeal against the EA, submit a notice of intention to appeal within 20 days of the date of the EA. with the Minister of Water and Environmental Affairs (the Minister).
4. After having submitted your notice of intention to appeal to the Minister, provide each registered IAP with a copy of the notice of intention to appeal within 10 days of lodging the notice.	4. After having submitted your notice of intention to appeal to the Minister, provide the applicant with a copy of the notice of intention to appeal within 10 days of lodging the notice.
5. The Applicant must also serve on each IAP: • a notice indicating where and for what period the appeal submission will be available for inspection.	5. Appellant must also serve on the Applicant within 10 days of lodging the notice, • a notice indicating where and for what period the appeal submission will be available for inspection by the applicant.
6. The appeal must be submitted in writing to the Minister within 30 days after the lapsing of the period of 20 days provided for the lodging of the notice of intention to appeal.	6. The appeal must be submitted to the Minister within 30 days after the lapsing of the period of 20 days provided for the lodging of the notice of intention to appeal.
7. Any IAP who received a notice of intention to appeal may submit a responding statement to that appeal to the Minister within 30 days from the date that the appeal submission was lodged with the Minister.	7. An Applicant who received notice of intention to may submit a responding statement to the appeal to the Minister within 30 days from the date that the appeal submission was lodged with the Minister.

NOTES:

1. **An appeal against a decision must be lodged with:-**
   a) the Minister of Water and Environmental Affairs if the decision was issued by the Director- General of the Department of Environmental Affairs (or another official) acting in his/ her capacity as the delegated Competent Authority;
   b) the Minister of Justice and Constitutional Development if the applicant is the Department of Water Affairs and the decision was issued by the Director- General of the Department of Environmental Affairs (or another official) acting in his/ her capacity as the delegated Competent Authority;

2. **An appeal lodged with:-**
   a) the Minister of Water and Environmental Affairs must be submitted to the Department of Environmental Affairs;
   b) the Minister of Justice and Constitutional Development must be submitted to the Department of Environmental Affairs;

3. **An appeal must be:-**
   a) submitted in writing;
   b) accompanied by:
   - a statement setting out the grounds of appeal;
   - supporting documentation which is referred to in the appeal; and
   - a statement that the appellant has complied with regulation 62 (2) or (3) together with copies of the notices referred to in regulation 62.

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Integrated Environmental Authorisation Issued in terms of

The National Environmental Management Act, 1998 and the Environmental Impact Assessment Regulations 2010

and

The National Environmental Management: Waste Act, 2008 and Government Notice 718 of 2009

Immediate and short term interventions for treatment of acid mine drainage in the Western, Central and Eastern Basins of the Witwatersrand Gold Fields, Gauteng Province

West Rand District Municipality, Ekurhuleni and City of Johannesburg Metropolitan Municipalities

Authorisation register number:	*12/12/20/2403*
Last amended:	*First Issue*
Holder of integrated authorisation:	*Department of Water Affairs*
Location of activities:	*GAUTENG PROVINCE:* ***Western Basin*** *– Krugersdorp, Witpoortjie and Randfontein* ***Central Basin*** *– From Durban Roodepoort Deep to East Rand Proprietary Mines* ***Eastern Basin*** *– Boksburg, Brakpan, Springs and Nigel within Ekurhuleni Metropolitan Municipality, Randfontein and Mogale City Local Municipalities.*

This authorisation does not negate the holder of the authorisation's responsibility to comply with any other statutory requirements that may be applicable to the undertaking of the activity.

DECISION

The Department is satisfied, on the basis of information available to it and subject to compliance with the conditions of this integrated environmental authorisation ("the environmental authorisation") that the applicant should be authorised to undertake the NEMA EIA and NEMWA listed activities specified below.

Details regarding the basis on which the Department reached this decision are set out in Annexure "I" to this environmental authorisation.

NEMA EIA AND NEMWA ACTIVITIES AUTHORISED

By virtue of the powers conferred on it by NEMA, the NEMA EIA Regulations, 2010, NEMWA and Government Notice 718 of 3 July 2009 the Department hereby authorises –

DEPARTMENT OF WATER AFFAIRS

with the following contact details –

Mr. Bashan Govender
Deparment of Water Affairs
Private Bag X995
PRETORIA
0001

Tel:	(012) 392-1306
Fax:	(012) 392-1359
Cell:	(082) 807-3522
E-mail:	govenderb@dwa.gov.za

to undertake all activities required for the commission of the works as described in the scoping report dated November 2012 at:

Alternative S1	Latitude	Longitude
Western Basin Site	26°8'23.074"S	27°42'13.018"E
Central Basin Site	26°13'3.277"S	28°10'56.877"E
Eastern Basin Site	26°15'5.173"S	28°29'19.461"E

Basin	Farm Name	Portion Number
	AMD Abstraction	
Western	Uitvalfontein 244 IQ	Remainder
Central	Driefontein 87 IR	Remainder of portion 1
Eastern	Grootvally Small Holdings	Holdings 100 - 106
	Treatment Plants	
Western	Randfontein 247 IQ	Portion 1 R/E
Central	Driefontein 87 IR	Remainder of portion 1
Eastern	Grootvally Small Holdings	Holdings 100 - 106
	Discharge Points	
Western	Waterval 174 IQ	Remaining Extent
Central	Driefontein 682 IR	Remainder
Eastern	Grootvally Small Holdings	Holdings 100 - 106

- for the implementation of emergency works aimed at mitigating acid mine drainage in the Witwatersrand Gold Fields, within Mogale City and Randfontein Local Municipalities; City of Johannesburg and Ekurhuleni Metropolitan Municipalities hereafter referred to as "the property".

<u>The interventions proposed will include of the following activities:</u>

Immediate term interventions – Western Basin

Immediate AMD mitigation measures can be implemented practically in the Western Basin based on the following:

- Upgrading and retrofitting of the existing Rand Uranium Treatment Plant as the best opportunity in terms of treatment capacity and ease of implementation.

- Bringing the Rand Uranium Treatment Plant's additional treatment trains back into operation, after appropriate mechanical and electrical equipment has been installed.
- The potential AMD treatment capacity, including the existing single operational treatment train is estimated to be 26-32 Mℓ per day.

Short term interventions

Western Basin

The site of the proposed Western Basin AMD water treatment plant for the short term intervention is near to the existing Rand Uranium treatment plant. Short term intervention activities planned for the Western Basin will include:

- Abstraction of AMD via pumps in Shaft No. 8 at a depth to achieve the ECL of 1550 mamsl;
- The lowering of the current water table in the old mine workings to 165 m below surface by pumping an average of 53 Ml/day (peak of 60 Ml/day) from Shaft No. 8;
- Construction and operation of a new HDS treatment plant on the Randfontein Estates site;
- Construction of a treated water pipeline to a suitable discharge point on the Tweelopiespruit within the Krugersdorp Game Reserve; and
- Construction of waste sludge disposal pumps and pipeline to the West Wits Pit for the disposal of the sludge from the treatment process.

Central Basin

The proposed Central Basin AMD treatment plant is to be situated on the western portion of the ERPM South West Vertical (SWV) Shaft area. Activities will include:

- Abstraction of AMD via pumps in the SWV Shaft to keep the water from rising above the ECL at 150 m below the ERPM Cinderella East Shaft collar level (1 617 m) or 1467 mamsl;
- Pumping and treating an average of 72 Ml/day (peak of 84 Ml/day);
- Construction of a new HDS plant adjacent to the SWV shaft;
- Construction of a waste sludge pipeline to the Crown Knights Gold processing plant;
- Construction of a treated water pipeline to a suitable discharge point on the Elsburgspruit; and
- Investigation and planning for a possible future waste sludge pipeline to the ERGO Brakpan Tailings Storage Facility (TSF).

Eastern Basin

The proposed Eastern Basin AMD water treatment plant will be situated at the Grootvlei Mine Shaft No. 3. Activities will include:

- Abstraction of AMD via installed pumps in Grootvlei No. 3 shaft at a pump depth to achieve the ECL level of 1280 mamsl;
- Pumping and treating at an average of 106 Ml/day and a peak of 110 Ml/day;
- Construction of a new HDS treatment plant adjacent to the Grootvlei No. 3 shaft;
- Investigation and planning for the possible construction of a waste sludge pipeline to the Daggafontein, Brakpan and/or Grootvlei TSFs; and
- Construction of a treated water pipeline to a suitable discharge point on the Blesbokspruit

EXEMPTIONS

Further, the Department hereby exempts -

The Department of Water Affairs from the requirements of the Environmental Impact Assessment Regulations 2010 in terms of sub-regulations (50), (51) and (52), for the development of the immediate and short term interventions for the treatment of acid mine drainage in the western, central and eastern basins as identified in the application for exemption dated 27 November 2012 – and authorises the Department of Water Affairs to undertake all activities required for the undertaking of the works as described in the scoping report dated November 2012 on the footprint as identified above.

SCOPE OF AUTHORISATION

1. Authorisation is granted for the implementation of emergency works aimed at mitigating acid mine drainage in the Witwatersrand Gold Fields. The immediate and short term interventions for the treatment of acid mine drainage are hereby approved.
2. The Department shall by written notice to the holder of an environmental authorisation and exemption suspend with immediate effect an environmental authorisation if suspension of the authorisation is necessary to prevent harm or further harm to the environment.
3. The activities must commence within a period of three (3) years from the date of issue. If commencement of the activity does not occur within that period, the environmental authorisation and exemption lapse and a new application for an environmental authorisation must be made for the activities to be undertaken. Commencement with one activity in terms of this decision constitutes commencement of all authorised activities.
4. The holder of the environmental authorisation and exemption shall be responsible for ensuring compliance with the conditions contained in this decision. This includes any person acting on the holder's behalf, including but not limited to, an agent, servant, contractor, sub-contractor, employee, consultant or person rendering a service to the holder of the decision.
5. Any changes to, or deviations from, the project description set out in this authorisation must follow the amendment processes as prescribed in Chapter 4 (Parts 1-3) of the NEMA EIA Regulations, 2010 and be approved, in writing, by the Department before such changes or deviations may be effected. In assessing whether to grant such approval or not, the Department may request such information as it deems necessary to evaluate the significance and impacts of such changes or deviations and it may be necessary for the holder of the authorisation to apply for further authorisation in terms of the regulations.

Management of the activity

6. The construction Environmental Management Programme (EMPr) integrated as part of the Application for EA is hereby approved. This EMPr must be implemented and adhered to.

6.1. The approved EMPr must be implemented and strictly enforced during all construction phases of the project. It shall be seen as a dynamic document and shall be included in all contract documentation for all phases of the development when approved.

7. Changes to the EMPr which are environmentally defendable, shall be submitted to this Department for acceptance before such changes may be effected.
8. The Department reserves the right to request amendments to the EMPr should any impacts that were not anticipated be discovered.

Environmental control officer

9. The holder of this decision must appoint an independent Environmental Control Officer (ECO) with experience or expertise in the field for the construction phase of the development. The ECO will have the responsibility to ensure that the conditions referred to in this decision are implemented and to ensure compliance with the provisions of the EMPr.
10. The ECO must be appointed before commencement of any authorised activity.
11. Once appointed, the name and contact details of the ECO must be submitted to the Director: Compliance Monitoring of the Department.
12. The ECO must remain employed until all rehabilitation measures, as required for implementation due to construction damage, are completed and the site is ready for operation.

12.1. The ECO must:

12.2. Keep record of all activities on site, problems identified, transgressions noted and a schedule of tasks undertaken by the ECO.

12.3. Keep and maintain a detailed incident (including spillage of bitumen, fuels, chemicals, or any other material) and complaint register on site indicating how these issues were addressed, what rehabilitation measures were taken and what preventative measures were implemented to avoid re-occurrence of incidents/complaints.

12.4. Keep and maintain a daily site diary.

12.5. Keep copies of all reports submitted to the Department.

12.6. Keep and maintain a schedule of current site activities including the monitoring of such activities.

12.7. Obtain and keep record of all documentation, permits, licences and authorisations such as waste disposal certificates, hazardous waste landfill site licences etc. required by this facility.

12.8. Compile a monthly monitoring report.

Waste management control officer

13. The applicant must designate a Waste Management Control Officer (WMCO), who will monitor and ensure compliance and correct implementation of all conditions and provisions as stipulated in the environmental authorisation and approved EMP related to the authorised activities.
14. The WMCO must report any non-compliance with any environmental authorisation conditions or requirements or provisions of NEMWA to the Department through the means reasonably available.
15. The duties and responsibility of the WMCO should not be seen as exempting the holder of the environmental authorisation from the legal obligations in terms of the NEMWA.

Recording and reporting to the department

16. The holder of this authorisation must keep all records relating to monitoring and auditing on site and make it available for inspection to any relevant and competent authority in respect of this development.
17. All records and/or reports required or resulting from activities relating to this environmental authorisation must:

17.1. be legible;

17.2. be submitted as required and must form part of the external audit report;

17.3. if amended, the record and/or report must be amended in such a way that the original and any subsequent amendments remain legible and are easily retrievable; and

17.4. be retained in accordance with documented procedures which are approved by the Department.

18. All documentation e.g. audit/monitoring/compliance reports and notifications, required to be submitted to the Department in terms of this authorisation, must be submitted to the Director: Compliance Monitoring at the Department.
19. The holder of the environmental authorisation must keep records and update all the information referred to in Annexure II and submit this information to the Department on an annual basis.

Environmental audit report for construction

20. The holder of the authorisation must submit an environmental audit report to the Department within 30 days of completion of the construction phase (i.e. within 30 days of site handover) and within 30 days of completion of rehabilitation activities.

21. The environmental audit report must:
21.1. Be compiled by an independent environmental auditor;
21.2. Indicate the date of the audit, the name of the auditor and the outcome of the audit;
21.3. Evaluate compliance with the requirements of the approved EMP and this environmental authorisation;
21.4. Include measures to be implemented to attend to any non-compliances or degradation noted;
21.5. Include copies of any approvals granted by other authorities relevant to the development for the reporting period;
21.6. Highlight any outstanding environmental issues that must be addressed, along with recommendations for ensuring these issues are appropriately addressed;
21.7. Include a copy of this authorisation and the approved EMP
21.8. Include all documentation such as waste disposal certificates, hazardous waste landfill site licences etc. pertaining to this authorisation; and
21.9. Include evidence of adherence to the conditions of this authorisation and the EMP where relevant such as training records and attendance records.

Commencement of activities

22. An appeal under section 43 of the National Environmental Management Act (NEMA), Act 107 of 1998 (as amended), does not suspend an environmental authorisation or exemption, or any provisions or conditions attached thereto, or any directive, unless the Minister, MEC or delegated organ of state directs otherwise.
23. Should you be notified by the Minister of a suspension of the authorisation pending appeal procedures, you may not commence with the activity until such time that the Minister allows you to commence with such an activity in writing.

Notification to authorities

24. Prior written notice must be given to the Department that the activity will commence. Commencement for the purposes of this condition includes site preparation. The notice must include a date on which it is anticipated that the activity will commence.

Operation of the activity

25. Prior written notice must be given to the Department that the activity operational phase will commence.
26. The holder of this authorisation must compile an operational EMPr for the operational phase of the activity and submit to the Department for written approval prior to commencement of operations or alternatively, if the holder has an existing operational environmental management system, it must be amended to include the operation of the authorised activity.

Site closure and decommissioning

27. Should the activity ever cease or become redundant, the applicant shall undertake the required actions as prescribed by legislation at the time and comply with all relevant legal requirements administered by any relevant and competent authority at that time.

Leasing and alienation of the site

28. Should the holder of the environmental authorisation want to alienate or lease the site, he/she shall notify the Department in writing of such an intention at least 120 days prior to the said transaction. Should the approval be granted, the subsequent holder of the environmental authorisation shall remain liable to compliance with all authorisation conditions.

Transfer of environmental authorisation

29. Should the holder of the environmental authorisation transfer holdership of this environmental authorisation due to a change of ownership [as provided for in terms of S24E(c) of NEMA], he/she must apply in terms of Section 52 of NEMWA.
30. Should the transfer of holder ship of this environmental authorisation mentioned above be for any reason other than the change of ownership in the property, the holder of this environmental authorisation must inform the Department of any change in ownership in the property and must request an amendment to this environmental authorisation to reflect such change in ownership.
31. Any subsequent holder of an environmental authorisation shall be bound by conditions of this environmental authorisation.

Investigations

32. If, in the opinion of the Department, pollution, nuisances or health risks may be or are occurring on the site, the holder of the environmental authorisation must initiate an investigation into the cause of the problem or suspected problem, including such investigations as identified by the Department related to the risks posed. Should the investigation carried out reveal any unacceptable levels of pollution, the holder of the environmental authorisation must submit mitigation measures to the satisfaction of the relevant Department.

Specific conditions

Site Security and Access Control

33. The holder of the environmental authorisation must ensure effective access control to the construction sites to prevent unauthorised entry. Weather-proof, durable and legible signs in at least three official languages applicable in the area must be displayed at each entrance to the site. The signs must indicate the risks involved in entering the site, must include the person responsible for the operation of the site.

Permissible waste

34. Any portion of the site which has been constructed or developed in accordance with this environmental authorisation may be used for the storage of sludge before treated and disposed.
35. The classification, acceptance and disposal criteria as listed in the latest edition of the document "Minimum Requirements for Handling, Classification and Disposal of Hazardous Waste, Waste Management Series, Department of Water Affairs and Forestry or by the Department in future, (hereinafter referred to as the "Minimum Requirements Series"), must be conformed to.

Construction and commissioning of activities

36. The site construction (existing and new) must be approved by a registered professional engineer and compliant with recognised civil engineering standards and adequately lined to protect surface and ground water resources.

37. The storage site must have a firm, impermeable, and chemical resistant floors and a roof to prevent direct sunlight and rain water from getting in contact with the sludge.
38. The holder of the environmental authorisation must construct and maintain on a continuous basis a drainage and containment system capable of collecting and storing all runoff water arising from the site, which could be expected as a result of the of the 1 in 100 years flood over a period of 24 hours to prevent such runoff water from coming into contact with waste. The system must under the said rainfall event, maintain a freeboard of half a metre.
39. The site plan must only be changed under the supervision of a registered professional engineer.

Environmental auditing and reporting

40. Internal Audits

40.1. Internal audits must be conducted annually by the holder of the environmental authorisation in order to audit compliance with conditions related to the treatment works of this environmental authorisation and the approved EMPr, and on each audit occasion an official report must be compiled by the relevant auditor to report the findings of the audits, which must be made available to the external auditor specified in condition below.

41. External Audits

41.1. The holder of the environmental authorisation and approved EMPr must appoint an independent external auditor to audit the treatment works biannually subject to the environmental authorisation and this auditor must compile an audit report documenting the findings of the audit, which must be submitted by the holder of the environmental authorisation.

41.2. The audit report must-

(i) Indicate compliance to requirements related to the treatment works as included in the approved operational EMPr for the treatment works;

(ii) Specifically state whether conditions related to the treatment works of this environmental authorisation are adhered to;

(iii) Include an interpretation of all available data and test results regarding the operation of the site and all its impacts on the environment;

(iv) Specify target dates for the implementation of the recommendations by the holder of the environmental authorisation to achieve compliance;

(v) Contain recommendations regarding non-compliance or potential non-compliance and must specify target dates for the implementation of the recommendations by the holder of the environmental authorisation and whether corrective action taken for the previous audit non conformities was adequate;

(vi) Show results graphically and conduct trend analysis; and

(vii) Include the information required in Annexure II.

41.3. The holder of the environmental authorisation must carry out all tests required in terms of this environmental authorisation in accordance with published laboratory analysis methods or those prescribed by and obtainable from the South African Bureau of Standards (SABS), referred to in the Standards Act, 2008 (Act 08 of 2008).

41.4. Each external audit report referred to in *External Audits* above must be submitted to the Department within 30 days from the date on which the external auditor finalised the audit.

Reporting

42. The holder of the environmental authorisation must, within 14 days inform the Department from the occurrence or detection of any incident referred to hereunder, within 14 days period of time specified by the Department submit an action plan, which must –

42.1. Correct the impact resulting from the incident;

42.2. Prevent the incident from causing any further impact; and

42.3. Prevent a recurrence of a similar incident to the satisfaction of the Department.

43. In the event that measures have not been implemented within 21 days of the incident, or within the time period identified by the Department, or the measures which have been implemented are inadequate, the Department may implement the necessary measures at the cost and risk of the holder of the environmental authorisation.

44. The holder of the environmental authorisation must keep an incident report and complaints register, which must be made available to the external auditor, representatives of this Department and Department of Water Affairs for the purpose of audit.

45. The Department must be notified as soon as the holder of this environmental authorisation becomes aware of the following incidents:

45.1. Any malfunction, breakdown or failure of equipment or techniques, accident or fugitive emission which has caused , is causing or may cause significant pollution;

45.2. The breach of this environmental authorisation; and

45.3. Any significant adverse environmental and health effects.

General operation and impact management of waste management activities

46. Waste, which is not sewage from the authorised development, must be dealt with according to relevant legislation or the Department's policies and practices.
47. The holder of environmental authorisation must prevent spillages. Where the spillages occur, the holder of authorisation must ensure the effective and safe cleaning of such spillages.
48. The treatment of effluent must not impact on a water resource or on any other person's water use, property or land and must not be detrimental to the health of the public in the vicinity of the activity.
49. The holder of environmental authorisation must prevent the occurrence of nuisance conditions or health hazards.
50. The pipelines used for the conveyance of effluent must be painted in a conspicuous colour or manufactured of a coloured material distinctly different from the colour of the pipes in which drinking water is flowing to avoid the possibility of any cross-connection of the different pipelines.
51. The holder of environmental authorisation must ensure that all personnel who work with hazardous waste are trained to deal with these potential hazardous situations so as to minimise the risks involved. Records of training and verification of competence must be kept by the Authorisation Holder.
52. The holder of authorisation must ensure that the effluent treatment operates within its design parameters at all times.
53. The holder of environmental authorisation must ensure that non biodegradable solids and the sludge are disposed of at a Waste Management Facility licensed to accept such wastes.
54. The holder of environmental authorisation must take all reasonable steps to ensure that the integrity of the waterproof base and infrastructure used for the treatment of acid mine water are routinely monitored and corrective action must be taken before containment integrity is breached.
55. No effluent must be discharged into any storm water drain or furrow, whether by commission or by omission.

Water quality monitoring

56. Surface water monitoring shall be performed in all storm water drains on and adjacent to the Site at locations selected in conjunction with the Department of Water Affairs and at such a frequency as determined by the responsible authority.
57. A proper macro element groundwater quality monitoring program must be implemented as soon as possible to establish baseline prior to the installation of the new treatment facilities.
58. A water quality monitoring program should be developed by a suitably qualified (SACNASP registered) person to allow for groundwater and surface water contamination monitoring.

59. Shallow monitoring wells must be installed around the treatment facilities.

60. Reasonable steps must be taken to ensure that the integrity of the waterproof base and infrastructure are routinely monitored and corrective action is taken before containment integrity is breached.

Date of environmental authorisation: 07/01/2013

Mr Mark Gordon
Chief Director: Integrated Environmental Authorisations
Department of Environmental Affairs

Annexure I: Reasons for Decision

1. Key factors considered in making the decision

All In reaching its decision, the Department took, *inter alia,* the following into consideration -

a) The information contained in the FSR dated November 2012;
b) Motivation Report in support of application for exemption dated November 2012;
c) The mitigation measures included in the construction EMPr dated November 2012;
d) The information contained in the Public Participation Process Report dated November 2012;
e) The comments from interested and affected parties as included in the FSR dated November 2012; and in the Public Participation Process Report dated November 2012;
f) The findings of the site inspection conducted on 02 November 2011; and
g) The objectives and requirements of relevant legislation, policies and guidelines, including section 2 of the National Environmental Management Act, 1998 (Act No. 107 of 1998).

2. Findings

After consideration of the information and factors listed above the Department reached the following conclusions:

a) The IMC Report indicated that these interventions are urgently required as the prevention of AMD decant in the basins is considered to be of national importance.
b) The impacts on the environment of the activity have been considered and are regarded as being mitigatable. The consequences to the surrounding environment should the activity not go ahead is however the major area of concern.
c) Allowing untreated mine water to enter into the environment in an uncontrolled manner is more likely to be detrimental to the environment than pre-treating the water and releasing it in a controlled manner.
d) The procedure followed for impact assessment is adequate for the decision-making process.
e) The proposed mitigation of impacts identified and assessed adequately curtails the identified impacts.

f) A sufficient public participation process was undertaken and the applicant has satisfied the minimum requirements as prescribed in the EIA regulations, 2010, for public involvement.

In view of the above, the Department is satisfied that, subject to compliance with the conditions contained in the environmental authorisation, the activities will not conflict with the general objectives of integrated environmental management laid down in Chapter 5 of the National Environmental Management Act, 1998 and that any potentially detrimental environmental impacts resulting from the activity can be mitigated to acceptable levels. The application is accordingly granted.

ANNEXURE II

INFORMATION WHICH SHALL BE SUBMITTED ON AN BI-ANNUAL BASIS IN ACCORDANCE WITH THE "RECORDING AND REPORTING TO THE DEPARTMENT" ABOVE

* = *Indicate with an X. Please print legibly.*

NAME OF SITE: ________________________________ DATE OF REPORT: _______(y/m/d)

1. Registered owner(s) of property on which the treatment facility is situated:

Name	Telephone	
Postal Address	Fax	
	Postal Code	

2. Operator in control of the treatment facility:

Name		Telephone	
Identity number		Tel. After hours	
Educational Qualifications			
Other Relevant competencies:			

3. Indicate the type of waste and approximate quantities of effluent treated during the six months:

Type of waste (Specify)	Quantity (m^3 $annum^{-1}$)
TOTAL	

4. Indicate the type of waste and approximate quantities of sludge reused, recycled, or disposed of during the six months:

Type of waste	Quantity (m^3 $annum^{-1}$)	reused, treated or disposed
TOTAL		

I, the undersigned, declare that the information stated above is to my knowledge a true reflection of the status at the ____________________ effluent treatment facility.

Signature: ____________________________

Name: ____________________________

Capacity: ______________________________

Place: ___________________ Date_______________

This form may be obtained electronically from the Department.

Appendix A
Mining Basins: Base Map

PROJECT TEAM:	DISCLAIMER:
Aurecon AME (LTD) in association with aurecon SRK Consulting (South Africa) (Pty) Ltd and Turner & Townsend (Pty) Ltd srk consulting Turner & Townsend	The Consortium gives no warranty of any kind, expressed or implied, with regard to the data and shall not be held liable in any event for any loss or damage in connection with or arising out of the use of this data. The data remains the sole property of the CLIENT and may not be used in any manner,without prior written approval of the CLIENT.

LEGEND:

- SHAFTS
- STS WESTERN TREAMENT PLANT
- STS ABSTRATION SITES
- STS SLUDGE DISPOSAL SITE
- STS TREATED WATER DISCHARGE PIPE
- STS SLUDGE REMOVAL PIPELINE
- STS WESTERN ABSTRACTION PIPELINE
- WESTERN BASIN BOUNDARY
- CENTRAL BASIN BOUNDARY
- EASTERN BASIN BOUNDARY
- KRUGERSDORP NATURE RESERVE
- CRADLE OF HUMANKIND
- SHAFTS
- WWTW
- NATIONAL ROADS
- MAIN ROADS
- RAILWAY LINE
- DAMS
- NON-PERENNIAL RIVERS
- PERRENIAL RIVERS

ACID MINE DRAINAGE FEASIBILITY STUDY

BASE MAP

CLIENT:

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

C:\PROJECTS\107748_ASSET MINE DRAINAGE\WORKSPACES\
107748_DRAINAGE BASINS_BASE MAP_11052012.WOR

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2 0 2 4
Kilometers

Scale: 1:120 000

DATE: MAY 2012

VERSION 1.3

Appendix B
Western Basin: Base Map

PROJECT TEAM:

Aurecon AME (LTD)
in association with

aurecon

SRK Consulting (South Africa) (Pty) Ltd and Turner & Townsend (Pty) Ltd

srk consulting

Turner & Townsend

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LEGEND:

- SHAFTS
- STS WESTERN TREAMENT PLANT
- STS ABSTRATION SITES
- STS SLUDGE DISPOSAL SITE
- STS TREATED WATER DISCHARGE PIPE
- STS SLUDGE REMOVAL PIPELINE
- STS WESTERN ABSTRACTION PIPELINE
- WESTERN BASIN BOUNDARY
- CENTRAL BASIN BOUNDARY
- EASTERN BASIN BOUNDARY
- KRUGERSDORP NATURE RESERVE
- CRADLE OF HUMANKIND
- SHAFTS
- WWTW
- NATIONAL ROADS
- MAIN ROADS
- RAILWAY LINE
- DAMS
- NON-PERENIAL RIVERS
- PERRENIAL RIVERS

ACID MINE DRAINAGE FEASIBILITY STUDY

WESTERN BASIN

CLIENT:

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

C:\PROJECTS\107748_ASSET MINE DRAINAGE\WORKSPACES\
107748_DRAINAGE BASINS_BASE MAP_WESTERN_11052012WOR

Kilometers

Scale: 1:40 000

DATE: MAY 2012

VERSION 1.3

Appendix C
Central Basin: Base Map

PROJECT TEAM:

Aurecon AME (LTD)
in association with

aurecon

SRK Consulting (South Africa) (Pty) Ltd and Turner & Townsend (Pty) Ltd

srk consulting

Turner & Townsend

DISCLAIMER:

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LEGEND:

SHAFTS
STS WESTERN TREAMENT PLANT
STS ABSTRATION SITES
STS SLUDGE DISPOSAL SITE
STS TREATED WATER DISCHARGE PIPE
STS SLUDGE REMOVAL PIPELINE
STS WESTERN ABSTRACTION PIPELINE
WESTERN BASIN BOUNDARY
CENTRAL BASIN BOUNDARY
EASTERN BASIN BOUNDARY
KRUGERSDORP NATURE RESERVE
CRADLE OF HUMANKIND
SHAFTS
WWTW
NATIONAL ROADS
MAIN ROADS
RAILWAY LINE
DAMS
NON-PERENNIAL RIVERS
PERRENIAL RIVERS

ACID MINE DRAINAGE FEASIBILITY STUDY

CENTRAL BASIN

CLIENT:

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

C:\PROJECTS\107748_ASSET MINE DRAINAGE\WORKSPACES\
107748_DRAINAGE BASINS_BASE MAP_CENTRAL_11052012.WOR

1 0 1 2
Kilometers

Scale: 1:60 000

DATE: MAY 2012

VERSION 1.3

Appendix D
Eastern Basin: Base Map

PROJECT TEAM:	DISCLAIMER:	LEGEND:
Aurecon AME (LTD) in association with aurecon SRK Consulting (South Africa) (Pty) Ltd and Turner & Townsend (Pty) Ltd srk consulting Turner & Townsend	The Consortium gives no warranty of any kind, expressed or implied, with regard to the data and shall not be held liable in any event for any loss or damage in connection with or arising out of the use of this data. The data remains the sole property of the CLIENT and may not be used in any manner,without prior written approval of the CLIENT.	SHAFTS STS WESTERN TREAMENT PLANT STS ABSTRATION SITES STS SLUDGE DISPOSAL SITE STS TREATED WATER DISCHARGE PIPE STS SLUDGE REMOVAL PIPELINE STS WESTERN ABSTRACTION PIPELINE WESTERN BASIN BOUNDARY CENTRAL BASIN BOUNDARY EASTERN BASIN BOUNDARY KRUGERSDORP NATURE RESERVE CRADLE OF HUMANKIND SHAFTS WWTW NATIONAL ROADS MAIN ROADS RAILWAY LINE DAMS NON-PERRENIAL RIVERS PERRENIAL RIVERS

ACID MINE DRAINAGE FEASIBILITY STUDY

EASTERN BASIN

CLIENT:

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

C:\PROJECTS\107748_ASSET MINE DRAINAGE\WORKSPACES\
107748_DRAINAGE BASINS_BASE MAP_EASTERN_11052012WOR

2 0 2 4
Kilometers

Scale: 1:80 000

DATE: MAY 2012

VERSION 1.3

Appendix E
Environmental Comments on the Short-Term Intervention

Comments on the Short term infrastructure to assess long term sustainability (environment & surface water quality)

<table>
<tr><th colspan="3">Western Basin</th></tr>
<tr><th>Key Infrastructure description</th><th>Discussion</th><th>Comment on long term sustainability / Implications for long term Scope of Works (inception report)</th></tr>
<tr><td>General</td><td>Brownfields receiving environment:
• The receiving environment for the project components is a “brownfields” area, largely consisting of mine-owned land;
• It appears that no sensitive environmental features as per GDARD’s Conservation Plan, Version 3 (such as wetlands or rivers) are in close proximity to the proposed key project components, save for the Tweelopies Spruit (the eventual discharge point for treated water);
Placement of infrastructure on private mining land:
• Although the issue has been addressed in contracts with TCTA, positioning of infrastructure (especially a treatment plant) on private land poses a risk for the Long-Term Solution, for the following reasons:
    o Private land used for the short term is typically held by a mining house, and associated mining right, and closure liability;
    o Legal risks associated with the financial situation of the mining company, mining license and closure costs (in terms of the NWA / MPRDA) must be considered;
• Co-disposal on Tailings Storage Facilities (TSF’s) of reworked tailings is mentioned as an attractive option. Long-term legal liability and apportionment of closure cost due to co-disposal of waste sludge on private mining land is a further risk, which could become an expensive item for DWA;
• Legal liability in terms of the NWA and NEM: WA (Waste Act) must also be assessed, as a mining house is typically not a licensed waste disposal facility, hence the waste being disposed of remains the responsibility of the DWA.</td><td>• Brownfields site must preferably be used for all project components of the Long-Term Solution;
• The residual legal responsibility entered into when partnering with a mining house on private land, is a significant risk for DWA in the long-term, of which the costs cannot currently be accurately defined;
• Requirements of the NWA and NEMWA must be taken into consideration (especially regarding receiving and disposing of waste);
• A site walk over should be conducted to ensure there are no sensitive environmental features such as wetlands and rivers</td></tr>
<tr><td>Abstraction point:
Abstraction of AMD via installed pumps in Rand Uranium’s Shaft No. 8 at a depth to achieve the ECL</td><td>• No comment</td><td>• The abstraction point in the Western Basin can have impacts on the groundwater system. Bringing the groundwater level down to the ECL, can change groundwater flow directions and associated pollution. The pollution can be drawn to the point of abstraction. The quality of the water abstracted from Shaft No 8 can therefore deteriorate with time.</td></tr>
</table>

Western Basin		
Key Infrastructure description	**Discussion**	**Comment on long term sustainability / Implications for long term Scope of Works (inception report)**
AMD pipeline to treatment plant: No clear indication is provided of the position of the pipeline	• High environmental risk for spillage – pipeline must be as short as possible (the distance between the extraction point and treatment plant is approximately 8 km).	• Proper maintenance of the pipe in long term is required to manage risk of failure and subsequent environmental incident.
Position of treatment plant: Construction of a new high density sludge (HDS) treatment plant on the Randfontein Estates site	• Refer to general comments above regarding land ownership and mine rights; • No environmental comment.	• No fatal flaws identified for short term, however land ownership and closure risks must be considered for long term. • The geology and geological lineaments in the vicinity of the treatment plant must be investigated as groundwater pollution can occur which will in turn lead to surface water pollution at groundwater discharge points.
Treated water pipeline to surface water discharge point: Construction of a treated water pipeline to a suitable discharge point on the Tweelopies Spruit, flowing to the Crocodile West Catchment	• Low environmental risk (good quality water) – no restriction on length; • Present Ecological State of Tweelopies Spruit is currently class F; • “suitable discharge point” was not clearly defined (it appears to be south of the Krugersdorp Game Reserve) • Existing negative impacts on the ecology and fauna of the Krugersdorp Game Reserve must be considered; • Flooding risk due to increase in base flow during summer months is significant for such a small system.	• Discharge point must be so located in the long-term to prevent impacts on the game reserve; • On-going monitoring of treated water discharge must be implemented to ensure that it meets the standards as per the Government Directive (Annexure C). • Flooding risk and impact of greater water volume in the system has not been assessed due to a lack of flow data; • North (downstream of the Krugersdorp Game Reserve) – this may be prohibited by cost, and may not be necessary, given the anticipated good quality of treated water.
Waste sludge pipeline to disposal point: Construction of waste sludge disposal pumps / a pipeline to the old opencast pits, including West Wits Pit and the Training Centre Pit.	**Sludge pipeline:** • High environmental risk for spillage (given the gypsum sludge properties) – must be as short as possible; • Exact position of West Wits and Training Centre pits are not provided; • Refer to general comment on brownfields site and sensitivity of the receiving environment above. **Old opencast pits:** • Chemical and physical properties of the waste sludge are not yet confirmed (suitability for co-disposal uncertain);	**Sludge Pipeline:** • High level of maintenance and management of the pipe in long-term is required to manage risk of failure and subsequent environmental incident. **Sludge disposal:** • Apportionment of closure liability must be considered in co-disposal of waste

Western Basin		
Key Infrastructure description	**Discussion**	**Comment on long term sustainability / Implications for long term Scope of Works (inception report)**
	• Short site life of West Wits Pit (3-5) years is not suitable for long term.	sludge with mining companies (see general comment above). The environmental, hydrological and geohydrological impacts at the disposal point must also be considered.

Central Basin		
Key Infrastructure description	**Discussion**	**Comment on long term sustainability / Implications for long term Scope of Works (inception report)**

General	**Brownfields receiving environment:**
	• The receiving environment for the project components is a “brownfields” area, largely consisting of mine-owned land;
	• It appears that no sensitive environmental features as per GDARD’s Conservation Plan v3 (such as wetlands or rivers) are in close proximity to the proposed key project components, save for the Elsburgspruit (the eventual discharge point for treated water);
	Placement of infrastructure on private mining land:
	• Although the issue has been addressed in contracts with TCTA, positioning of infrastructure (especially a treatment plant) on private land poses a risk for the Long-Term Solution, for the following reasons:
	  ○ Private land used for the short term is typically held by a mining house, and associated mining right, and closure liability;
	  ○ Legal risks associated with the financial situation of the mining company, mining license and closure costs (in terms of the NWA / MPRDA) must be considered;
	• Co-disposal on TSF’s of reworked tailings is mentioned as an attractive option. Long term legal liability / apportionment of closure cost due to co-disposal of waste sludge on private mining land, is a further risk, which could become an expensive item for DWA;
	• Legal liability in terms of the NEM: WA (Waste Act) must also be assessed, as a mining house is typically not a licensed waste disposal facility, hence the waste being disposed of remains the responsibility of the DWA.
		• Brownfields site must preferably be used for all project components of the Long-Term Solution;
		• The residual legal responsibility entered into when partnering with a mining house on private land, is a significant risk for DWA in the long-term, of which the costs cannot currently be accurately defined;
		• Requirements of the NWA and NEM:WA must be taken into consideration (especially regarding receiving and disposing of waste);
		• A site walk over should be conducted to ensure there are no sensitive environmental features such as wetlands and rivers

Abstraction point: Abstraction of AMD via installed pumps in the South West Vertical (SWV) Shaft (either to pump to the ECL or to the Central Rand Gold-proposed mining level of 400 m below SWV Shaft level)	• No comment.	• No fatal flaws identified
AMD pipeline to treatment plant: No pipeline required for HDS Plant at SWV Shaft.	• The abstraction and treatment plant is on the same site, which is ideal, in that an AMD pipeline is not required for the Short-Term Intervention.	• Proper maintenance of the treatment plant in long term is required to manage risk of failure and subsequent environmental incident.
Position of treatment plant: • Construction of a new HDS plant	• Refer to general comments above regarding land ownership and mine rights;	• No fatal flaws identified for short term, however land ownership and closure

Central Basin		
Key Infrastructure description	**Discussion**	**Comment on long term sustainability / Implications for long term Scope of Works (inception report)**
at SWV Shaft.	• Positioning of the treatment plant on same site as the abstraction point is positive for reducing short term environmental risk.	risks must be considered for long term • The geology and geological lineaments in the vicinity of the treatment plant must be investigated as groundwater pollution can occur which will in turn lead to surface water pollution at groundwater discharge points.
Treated water pipeline to surface water discharge point: • Construction of a treated water pipeline to a suitable discharge point on the Elsburgspruit (Vaal River Catchment).	• Low environmental risk (good quality water) – no restriction on length; • Elsburgspruit is considered of moderate (not high) conservation importance in terms of the GDARD Conservation Plan, Version 3. • Flooding risk due to increase in base flow during summer months is significant.	• No fatal flaws for water discharge point; • Flooding risk must be assessed for long term (given the high density of residential land use downstream)

Waste sludge pipeline to disposal point:
• Construction of a 3km waste sludge pipeline to the DRD Gold (Crown) Knights Gold Plant (5-6 years short term);
• Investigation and planning for a future waste sludge pipeline to the ERGO Brakpan tailings storage facility (TSF);
• Alternatively, to ERPM's old underground workings
	Sludge pipeline:
	• High environmental risk for spillage (given the gypsum sludge properties) – must be as short as possible;
	• Refer to general comment on brownfields site and sensitivity of the receiving environment above;
	• SWV Shaft to DRD Gold Knights Gold Plant – short distance over brownfields site, hence low risk;
	• SWV Shaft to ERGO Brakpan TSF – pipeline route is estimated at 25km, and environmental risk of pipe failure is significant.
	
	Sludge disposal:
	• **ERGO Brakpan TSF** - Long term stability of AMD treatment sludge disposed with tailings is generally unknown, and sludge dissolution / metal mobilisation remains a risk (suitability for co-disposal uncertain);
	• **ERPM underground workings –** although this option requires additional groundwater modelling, it is economically and environmentally attractive, due to
	  ○ Reduction of required footprint;
	  ○ Elimination of potential for surface water pollution;
	  ○ Reduction of potential for subsidence;
	  ○ Reduction of the acidity of mine water.
		Sludge Pipeline:
		• No fatal flaws identified with Short-Term Intervention;
		• High level of maintenance and management of the pipe in long term is required to manage risk of failure and subsequent environmental incident;
		• Long-Term Solution (>6 years) must be identified and assessed by long-term team study (no detail in short-term).
		
		Sludge disposal:
		• Apportionment of closure liability must be considered in co-disposal of waste sludge with mining companies (see general comment above);
		• Underground disposal appears to be economically and environmentally more sound than co-disposal with gold tailings for the long term.
		• The environmental, hydrological and geohydrological impacts at the disposal point must also be considered.

<table>
<tr><th colspan="3">Eastern Basin</th></tr>
<tr><th>Key Infrastructure description</th><th>Discussion</th><th>Comment on long term sustainability / Implications for long term Scope of Works (inception report)</th></tr>
<tr><td>General</td><td>Brownfields receiving environment:
The receiving environment for the project components, is a “brownfields” area, largely consisting of mine-owned land;
It appears that no sensitive environmental features as per GDARD’s Conservation Plan v3 (such as wetlands or rivers) are in close proximity to the proposed key project components, save for the Blesbok Spruit (the eventual discharge point for treated water) which is a Ramsar Site;
Placement of infrastructure on private mining land:
Although the issue has been addressed in contracts with TCTA, positioning of infrastructure (especially a treatment plant) on private land poses a risk for the Long-Term Solution, for the following reasons:
Private land used for the short term, is typically held by a mining house, and associated mining right, and closure liability;
Legal risks associated with the financial situation of the mining company, mining license and closure costs (in terms of the NWA / MPRDA) must be considered;
Co-disposal on TSF’s of reworked tailings is mentioned as attractive option. Long term legal liability / apportionment of closure cost due to co-disposal of waste sludge on private mining land is a further risk, which could become an expensive item for DWA;
Legal liability in terms of the NEM: WA (Waste Act) must also be assessed, as a mining house is typically not a licensed waste disposal facility, hence the waste being disposed of remains the responsibility of the DWA.</td><td>Brownfields site must preferably be used for all project components of the Long-Term Solution;
The residual legal responsibility entered into when partnering with a mining house on private land, is a significant risk for DWA in the long-term, of which the costs cannot currently be accurately defined;
Requirements of the NWA and NEM: WA must be taken into consideration (especially regarding the receipt and disposal of waste).
A site walk over should be conducted to ensure there are no sensitive environmental features such as wetlands and rivers</td></tr>
<tr><td>Abstraction point:
Abstraction of AMD via installed pumps in Grootvlei No. 3 shaft at a pump depth to achieve the ECL level or the level to allow Gold One to continue mining Sub Nigel No. 1 Shaft</td><td>No comment.</td><td>No fatal flaws identified.</td></tr>
<tr><td>AMD pipeline to treatment plant:
Very short pipeline required for HDS Plant south of Grootvlei Shaft no 3.</td><td>High environmental risk for spillage – The abstraction and treatment plant is practically on the same site, which is ideal, in that an AMD pipeline is not required for the Short-Term Intervention.</td><td>Proper maintenance of the pipe in long term is required to manage risk of failure and subsequent environmental incident.</td></tr>
</table>

<table>
<tr><th colspan="3">Eastern Basin</th></tr>
<tr><th>Key Infrastructure description</th><th>Discussion</th><th>Comment on long term sustainability / Implications for long term Scope of Works (inception report)</th></tr>
<tr><td>Position of treatment plant: Construction of a new High Density Sludge (HDS) treatment plant adjacent to the Grootvlei Shaft No. 3, on the agricultural small holding site south of the abstraction point.</td><td>Refer to general comments above regarding land ownership and mine rights;
Positioning of the treatment plant on same site as the abstraction point is positive for reducing short term environmental risk.</td><td>No fatal flaws identified for short term, however land ownership and closure risks must be considered for long term</td></tr>
<tr><td>Treated water pipeline to surface water discharge point: Construction of a treated water pipeline to a suitable discharge point on the Blesbokspruit (Vaal River Catchment).</td><td>Low environmental risk (good quality water) – no restriction on length;
“suitable discharge point” was not clearly defined
The Blesbokspruit Wetland is a listed RAMSAR site, and flooding of the system or washing out of the wetland soils in summer months (flooding and large water volumes being added to the normal seasonal flow) is a real concern, therefore it is proposed that the release point be downstream of the Spruit (opinion to be confirmed by wetland ecologist).
Failure of plant and resultant release of untreated AMD into the Blesbokspruit is potentially a significant impact.</td><td>Discharge point must be so located in the long term to prevent impacts on the Blesbokspruit;</td></tr>
<tr><td>Waste sludge pipeline to disposal point:
Construction of a waste sludge pipeline to the DRD Gold Daggafontein Gold Plant for co-disposal on the Daggafontein TSF.
Investigation and planning for a future waste sludge pipeline to the ERGO Brakpan tailings storage facility (TSF);
Alternatively, to the Eastern Basin’s old underground workings</td><td>Sludge pipeline:
High environmental risk for spillage (given the gypsum sludge properties) – must be as short as possible;
Refer to general comment on brownfields site and sensitivity of the receiving environment above;
Length of pipeline to Daggafontein procession plant is short-term only, and short enough for environmental risk to be managed;
Length of pipeline to ERGO TSF (more than 15km) is not optimal, due to environmental risk of failure.
Sludge disposal:
Co-disposal on TSF: Long-term stability of AMD treatment sludge disposed with tailings is generally unknown, and sludge dissolution / metal mobilisation remains a risk (suitability for co-disposal uncertain);
Underground disposal - although this option requires additional groundwater modelling, it is economically and environmentally attractive, due to
Reduction of required footprint;
Elimination of potential for surface water pollution;
Reduction of potential for subsidence;
Reduction of the acidity of mine water.</td><td>Sludge Pipeline:
High level of maintenance and management of the pipe in long term is required to manage risk of failure and subsequent environmental incident.
Sludge disposal:
Apportionment of closure liability must be considered in co-disposal of waste sludge with mining companies (see general comment above).
Underground disposal appears to be economically and environmentally more sound than co-disposal with gold tailings for the long term.</td></tr>
</table>

Appendix F
The Implications of the TCTA Proposed STI for the LTS

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Tables

THE IMPLICATIONS OF THE TCTA PROPOSED SHORT TERM INTERVENTION FOR THE LONG-TERM SOLUTION – 17 JULY 2012

1 INTRODUCTION

1.1 Background

Acid Mine Drainage (AMD) on the Rand mining areas has become a major environmental challenge.

Excessive dilution-releases from Vaal Dam will be required to curb the effects of sewage and AMD associated salt-loading on the Vaal River System and to maintain fitness for use of Vaal River water below Vaal Barrage, if these are not addressed. This will also result in unusable surpluses developing in the Lower Vaal River, externalising the cost of pollution to the Lower Orange River. Should the AMD issue not be addressed appropriately by 2014, water supply security in the Vaal River water supply area will be under threat, resulting in water restrictions becoming imminent.

To deal with AMD matters at a high level, an Inter-Ministerial Committee (IMC) comprising of the Ministers of Mineral Resources, Water and Environmental Affairs, Science and Technology and the Minister in the Presidency: National Planning Commission was established.

A Team of Experts was instructed to advise the IMC, in respect of AMD and specifically recommended the following Short-Term Interventions, which the IMC approved for emergency implementation:

- Water must be pumped from the three priority basins to maintain water levels at least below the relevant Environmental Critical Levels (ECLs); and
- The water to be pumped will need to be treated to correct the pH and to remove heavy metals prior to it being released to surface water resources.

In this regard the implementation of Short-Term Solutions (STS) is underway on authority of a directive issued by the Minister of Water Affairs to the Trans Caledon Tunnel Authority (TCTA) for emergency works related to AMD.

Apart from the Short-Term Solutions, Long-Term Solutions (LTS) need to be investigated. A team of consultants, led by Aurecon in association with SRK Consulting and Turner and Townsend, and supported by specialists from different institutions, was appointed on 30 January 2012 by the DWA to conduct a feasibility study of the LTS for the treatment of the

AMD in the Witwatersrand Goldfields. The team is responsible for conducting this study over a period of 13 months (ending in February 2013).

The objective of the study is to investigate and recommend a feasible LTS to the AMD situation emerging in the study area, in order to ensure long term water supply security and continuous fitness for use of Vaal River water. A feasible solution will be one that is technically sound, economically viable, institutionally feasible and legally acceptable. As such, this study's focus is not only on the technical aspects of a LTS (in terms of treatment options), but also on legal, economic, financial and institutional aspects.

The study area is restricted to the, Central and East to West Rand Mining Basins, which will be considered in the context of the Vaal River water supply area.

1.2 Purpose of this Document

The LTS Terms of Reference (ToR) requires integration between the Short-Term Intervention (STI) and the LTS. The Position Paper contains the current description of the implications of the STI for the LTS and if possible or necessary, how the LTS could influence the STI. The Position Paper is based on the ongoing detailed investigations, the findings of which are contained in various reports which are being produced. The reader should refer to those reports for more detailed discussion.

However, due to the manner in which the Study for the LTS is unfolding, there ongoing changes in a implication and some new implications are identified.

1.3 Scope of this Document

The opinions expressed in this report by the Professional Service Provider (PSP) for the Feasibility Study for the LTS are based on technical information (reports, drawings, etc.) gathered and assessed at the date of this report and on information obtained during meetings with a number of organisations, including TCTA and their consultants. The comments are provided from a technical and engineering perspective. This report does not consider the governance issues which have been raised in relation to the permanence of the infrastructure proposed by the STI or any land ownership, environmental or legal issues that may arise.

The Feasibility Study for the LTS only started in February 2012 about ten months after the directive was issued to TCTA, so the STI had to be planned and implemented without a Feasibility Study for the LTS to guide the process. This introduces limitations on the LTS and may have financial and other implications for the LTS. This means that future adjustments to the STI will probably be required and there will probably be some financial implications when the bidders allow for the risk of taking over existing assets and incorporating these assets into their design solution.

The implications of the proposed STI for a possible LTS are addressed under the following topics, but should be considered as a whole.

- Topic 1: General Implications of the STI for the LTS
- Topic 2: Alternative methods for abstracting AMD to prevent breach of the ECL
- Topic 3: The Long Term static water level (ECL) envisaged in the STI
- Topic 4: Pumping AMD from all three basins rather than only from one or two of the basins
- Topic 5: The location of the proposed abstraction points in the STI
- Topic 6: The selected pumps
- Topic 7: The proposed treatment technology
- Topic 8: Infrastructure type and location
- Topic 9: Points for water discharge to the environment
- Topic 10: Waste discharge sites
- Topic 11: Operation of the STI
- Topic 12: Land and land transfer issues
- Topic 13: Procurement issues

2 THE SHORT TERM INTERVENTION

The immediate objectives of the short term measures which are being implemented by TCTA are:

(i) Stop decant in the Western Basin and reduce water level to the Environmental Critical Level (ECL).
(ii) Prevent breach of ECL in the Central Basin: Currently predicted to occur in July 2013.
(iii) Prevent breach of ECL in the Eastern Basin: Currently predicted to occur in July 2014.

The directive to the TCTA, issued by the Minister of Water and Environmental Affairs on 6 April 2011 (MWEA 2011), instructed them to implement the recommendations, approved by the IMC and Cabinet, as emergency works. The recommendation inter alia comprises:

(i) Installation of pumps to extract water from the mines to on-site water treatment plants.
(ii) Construction of an on-site water treatment plant in each Basin with the option of refurbishing and upgrading the existing ones owned by the mines.
(iii) Installation of infrastructure to convey treated water to nearby water courses.
(iv) Operation of the pump stations and treatment works, etc.

The TCTA are implementing the following works:

(i) An immediate intervention in the Western Basin comprising: additional pumps installed in Rand Uranium Shaft 8 to give a total pumping capacity of 36 Mℓ/day.

    Upgrading and expanding the existing Rand Uranium treatment works to a design capacity 36 Mℓ/day.

    These immediate works are being commissioned in April and May 2012. They have the capacity to prevent the decant from the Western Basin during average conditions. Some decant may still occur sometime after periods of above average ingress.

(ii) A STI, in each of the three basins comprising:
    - Permanent pumps installed in existing shafts, designed to be capable of maintaining the static water level in each basin below the ECL proposed by the IMC, and as revised by TCTA after further assessment.

      In the Western Basin the immediate intervention will be operated in parallel with the STI to lower the water level to the ECL (proposed to 1 550 m amsl) in about February 2014. The immediate intervention will then be abandoned.

    - A high density sludge neutralisation plant in each basin, capable of neutralising and removing the majority of the heavy metals from the AMD being pumped from the void to the following standards:

Table 1: Target Mine Water Discharge Standards

Water Quality Variable	Units	Concentrations
pH	-	6-9
Iron (as Fe)	mg/ℓ	<1
Manganese (as Mn)	mg/ℓ	<3
Aluminium (as Al)	mg/ℓ	<1
Uranium (as U)	µg/ℓ	<50
Sulphate (as SO_4)	mg/ℓ	<2 400

- Sludge disposal in each basin.

- Pipelines, pump stations and appropriate services to:
  - Transfer the water from shaft pumps to the treatment works and then to nearby rivers in each basin; and
  - Transfer the waste product resulting from the HDS plant to a storage facility in each basin.

The TCTA Due Diligence Report proposed that the STI should be designed and constructed as the first phase of the LTS. The designs are thus appropriate for that purpose with design life of up to 50 years, depending on the component.

To meet the objectives of the STI and given the predicted dates to reach the ECL for the Central and Eastern Basins, and the required period for construction in the TCTA programme tenders for the construction in the Central Basin (ECL 1 467 m amsl) should have been awarded in March 2012 and in the Eastern Basin (ECL 1 280 m amsl) by October 2012. In the Western Basin, to meet the projected date for reducing the water level to ECL (1 550 m amsl), the tender needed to be awarded in April/May 2012. The tenders, as issued by TCTA, for works in all three basins, provide for flexibility in award. TCTA can award a contract for works in any or all of the basins and can delay award for one or more basins.

3 TOPIC 1: GENERAL IMPLICATIONS OF THE STI FOR THE LTS

3.1 Introduction

Whichever technical solution and procurement strategy are selected for the LTS, the fact that there are now some works addressing AMD and there will soon be more STI works, places constraints on and has implications for the LTS in terms of:

- Restrictions on alternative choices of infrastructure type and location; or accepting increased capital costs for long term operating efficiency; and
- Risk transfer.

These are summarised in the following sections with more details given in each of the main topics which follow.

3.2 Infrastructure

Whatever form of STI was implemented ("temporary works" or works designed to be Phase 1 of the LTS), it would place constraints on the LTS.

(i) Construction of temporary or emergency holding works

The emergency works would have to continue in operation until the LTS was able to take over the management of the AMD.

- It would thus have been necessary to ensure that the works had a life of at least 6 years to mid-2018 by when it could confidently be expected that the LTS would be commissioned. Depending on the programme for implementing the LTS, they may have only been required for two years and would probably not have been useful in the LTS.
- It also seems very unlikely that it would have been possible for the STI to have procured and installed temporary pumps capable of discharging the required volumes against the head from ECL to surface and the pumps being procured will be able to be used in the long term solution, even if they are relocated at some time.
- A significant, but unknown capital amount would thus have been spent to procure a 6 year "window of opportunity" to construct "permanent" abstraction and neutralisation infrastructure.
- The economics of investing in an emergency scheme and thus deferring the larger capital cost of the "permanent" first phase of the LTS has not been assessed in the Feasibility Study for the LTS.

The facilities used (shafts, etc.) and land occupied, by the "temporary works" would probably not be available for the LTS.

Now that the STI comprises permanent works, envisaged as the first phase of the LTS, it places constraints on the selection of the most economic LTS.

The choice of the LTS needs to take account of the STI and consider all of the following options:

- Incorporate all or part of the STI as the "front end" of the LTS, with or without modification; or
- Plan to abandon, or decommission all or part of the STI works that do not fit into the acceptable and most economic LTS, on a whole life cost basis;
- Re-relocate some of the STI to form part of the LTS in a different location.

The most appropriate option will be determined in the feasibility study for the LTS.

3.3 Risk Transfer

A number of procurement and implementation options exist with the first decision based on the funding mechanism. The two major funding options that exist for the capital required are

- Funding using government funds from the Revenue Account;
- Private sourced funding with or without a government capital contribution.

If the procurement strategy for the LTS is that Government will fund the capital required and that DWA will be the operator, then DWA will take on the solution design and operational risk of the STI.

In the case of the LTS being either a Government funded Design, Build, Operate, Maintain (DBOM) or privately funded PPP solution, then the Private Party will be expected to take over, maintain and operate the STI. The level of risk that Government will be able to transfer to the Private Party will be constrained. In order to be competitive on price, the Private Party will probably have to take over the extraction solution and technology solution designed into the STI, as well as the equipment selected and installed.

In any of the procurement and implementation scenarios, the party responsible for design and operation (a government or a private sector entity) will only be able to select the desalination technology downstream of the STI and the discharge of the "product" and the management of the wastes therefrom. This will mean that the party responsible will probably be locked into the STI design and operational framework.

In the case where a Private Party is responsible for design, construction and operations, it is likely that the Private Party will take over these risks provided that Government provides an indemnity for the equipment selected, installed, operated and maintained by TCTA and DWA. Irrespective of whether or not there was a STI the Private Party would also request an indemnity against a change in daily volume to be abstracted, outside the range allowed for in the contract, and the connectivity of the mining void to the abstraction point.

While National Treasury are strongly against providing indemnities to the Private Sector an indemnity in this instance for the latent defect risk implicit in the STI could well be shown to be value for money.

Further discussion is contained in Topic 13.

4 TOPIC 2: ALTERNATIVE METHODS FOR ABSTRACTING AMD TO PREVENT BREACH OF THE ECL

4.1 Description

In previous studies, five possible types of abstraction were considered:

(i) Allowing uncontrolled decant to surface.

(ii) Managed decant near the natural points of decant, with structures to control the flows, and channel to treatment works. The static water level would be essentially similar, as for (i) above.

(iii) Gravity flow through a tunnel constructed to intersect the void below the required static water level.

(iv) Constructing/drilling new boreholes into the void for pumped abstraction.

(v) Pumping water from the mine void at an existing shaft.

The STI opted for option (v).

4.2 Discussion

The only practical way to avoid breaching the ECL, or lowering water level in the mine void to the ECL is to make use of existing shafts for pumping, i.e. option (v).

Options (i) and (ii) (decant) do not meet the objectives of protecting the aquifers and certain man-made structures, including those near the decant points. In the Central and Eastern Basins there are several potential decant points, compounding the impacts and risks.

Given the time available to the STI options (iii) and (iv) could not have been implemented in time. They would have required pre-feasibility and feasibility studies to define the solution before design and construction could commence.

Option (iii) was considered for the Central Basin by the Council for Geo Science (CGS) and the IMC, but not recommended to the IMC. The report investigating this option has not yet been made available at the time of writing this document. This option would need detailed investigations, significant time to implement and would probably have a higher capital cost but with lower operating costs. It was not feasible for the STI but will be re-evaluated in the LTS. It is not a viable option for the Western Basin until the water level in the void is pumped to below ECL to allow the tunnel to connect to the void.

The possible benefits of drilling one or more boreholes, specifically for the Central Basin, are discussed under Topic 5 and will be considered in the LTS.

4.3 Risks for the LTS

There are no technical risks that could have been avoided in the implementation of option (v), but see Topic 5 for further considerations.

4.4 Mitigation Options

None required.

The option of a gravity tunnel will be considered in the LTS.

4.5 Implications

If a tunnel option is viable, the pumps for the STI may not be used for their full life in their proposed locations. They could be relocated if necessary.

5 TOPIC 3: THE LONG-TERM STATIC WATER LEVEL (ECL) ENVISAGED IN THE STI

5.1 Description

The IMC Report, approved by Cabinet, recommended a specific ECL for each basin.

The TCTA Due Diligence Report and subsequent tender documents proposed somewhat different levels, to achieve the same objectives as required by Cabinet of protecting shallow aquifers, dolomite formations and man-made structures such as building foundations. Details are given in Appendix A. Differences in the levels are not material.

5.2 Western Basin

5.2.1 Discussion

The ECL proposed by TCTA of 1 550 m amsl (IMC = 1 530 m amsl) is considered low enough to meet the requirements. However, it is possible that a level of 1 600 m amsl, may also achieve the objectives, specifically that of preventing AMD contamination of the dolomites of the Cradle of Humankind.

However, providing infrastructure for the conservative approach, proposed by the STI is appropriate does not preclude raising the level in due course, (see Section 5.2.3), and may be necessary for construction of some possible abstraction solutions.

The proposed average static water level allows sufficient freeboard for the water level to rise, after periods of above average ingress and for the level to be lowered drop with full time pumping.

5.2.2 Risks for the LTS

There are no risks for the LTS apart from the general risk of loss of connectivity through rock falls etc.

If pumping is the LTS then designing the pumping solution to suit the ECL of the STI will result in a satisfactory situation.

If a tunnel option proves viable, the tunnel will have to be located so that the water level will probably be drawn down to at least the ECL of the STI during construction.

5.2.3 Mitigation Options

If a higher ECL is proposed for the LTS and considered to have merits, the water level in the Western Basin can first be reduced to that level and recommended monitoring carried out to check if it is achieving the objective. If it is not, the STI infrastructure allows the water level to be progressively lowered, to 1 550 m asml, with monitoring to check when the objective has been achieved.

5.2.4 Implications

There are no negative implications.

The higher ECL would reduce the pumping costs.

5.2.5 Design

No changes are proposed or required.

5.3 Central Basin

5.3.1 Description

The STI proposed ECL is 1 467 m amsl if it is agreed to protect the Gold Reef City mine museum at 1 480 m amsl (IMC = 1 503 m amsl).

5.3.2 Discussion

The proposed ECL of 1 467 m amsl is acceptable to protect the near surface aquifers and man-made structures. However the lowest level of these aquifers is probably 1 520 m amsl, which would be the ECL.

The ECL of 1 520 m amsl is approximately 100 m below the lowest foundations of the buildings in the Johannesburg CBD (Winde 2011).

Monitoring and detailed investigations may allow it to be raised. Alternatively if any contamination is observed, it could easily be lowered.

The alternative level of 1 467 m amsl proposed by the STI to protect Gold Reef City Museum may not be low enough to protect the museum at 1 480 m amsl (freeboard 13 m) if the hydraulic gradient to SWV shaft is significant and/or there is a rise in static water level after high ingress or pump failure for a significant period.

Three possible static water levels are being considered by the LTS (see Appendix A).

- The highest ECL of 1 520m amsl to protect the aquifers, but not Gold Reef City Museum.
- The static water level of 1 467 m amsl, with the objective ensuring of protection the historic mine museum at Gold Reef City at 1 480 m amsl and the option of allowing it to rise when the water level at Gold Reef City is stable. This museum has social/historic, as

well as academic and economic benefits through being used as a training facility and a tourist attraction. This is not an ECL, but rather a Socio/Economic Critical Level (SECL).

The ECL of 1 278, which would allow CRG to resume mining down to that depth, using the SWV Shaft for their mining operations. This can rather be considered as an economic water level.

The pumps which are going to be installed in South West Vertical (SWV) Shaft were originally ordered by DRD and have the capability of pumping to maintain any of the static water levels that are proposed.

5.3.3 Risks for the LTS

If the ECL is set at 1 517 m amsl to protect the aquifers there should not be any risk to the aquifers provided adequate monitoring of water from boreholes, is maintained.

However, the Gold Reef City Museum will be below the ECL and will either have to be isolated from the surrounding mine void, by plugs or relocated to a higher level or abandoned.

If the static water level is maintained at 1 467 m amsl, i.e. 13 m below the level of the Gold Reef City Museum, there is a risk of flooding if the water level rises due to pump failure or high levels of ingress. The spare capacity in the proposed pumps may be adequate to address this but it needs to be verified.

If the static water level is maintained at 1 278 m amsl to allow mining through SWV Shaft, there is no risk to Gold Reef City Museum or the aquifers. The mine workings may be at risk through water level rise, depending on the level of the workings.

5.3.4 Mitigation Options

The mitigation would consist of careful monitoring and adjustment of pumping hours and pump levels as required to mitigate the risk of flooding.

5.3.5 Implications

There are no implications for the LTS other than the operating cost associated with each water level.

5.3.6 Design

No design changes are envisaged.

5.4 Eastern Basin

5.4.1 Description

The proposed ECL for the STI is 1 280 m amsl (IMC = 1 150 m amsl) to protect the overlying dolomitic formations from pollution.

5.4.2 Discussion

The ECL of 1 280 m amsl set to be below the bottom of the overlying dolomites, is considered to be low enough to prevent contamination of the aquifer, even though deep keels of dolomite protrude below this level.

Since the water level in the overlying dolomites is at or near surface, there is a strong downward flow through the dolomites and fractures connecting them to the mine voids. Providing the water level in the mine voids is low enough to maintain these flows, the dolomites should not become contaminated and a higher ECL as high as 1 470 m amsl could be considered.

5.4.3 Risks for the LTS

Apart from the normal risk associated with pumping there are no specific or significant identified risks with the ECL proposed by the STI.

5.4.4 Mitigation Options

Mitigation is not required.

5.4.5 Implications

The only implication for the LTS is the high cost of pumping from the proposed ECL. This could be reduced, by adopting an ECL as high as 1 470 m amsl, but careful monitoring will be required to confirm that the dolomite is not being contaminated by the AMD in the mine voids.

5.4.6 Design

No design changes are envisaged.

6 TOPIC 4: PUMPING AMD FROM ALL 3 BASINS RATHER THAN ONLY FROM ONE OR TWO OF THE BASINS

6.1 Description

The STI proposes pumping the AMD from one shaft in each of the three mine compartments.

The question has been asked if it is possible to pump from only one basin and still achieve the objectives.

6.2 Discussion

The studies carried out to date indicate that there is no interconnectivity between the basins so pumping the AMD from all 3 basins from any one location would require creating connectivity. While the Central and Eastern Basins are congruent, the Western Basin is isolated from the Central Basin by unmined rocks. Even if erecting an adequate connection was possible, it would introduce risks, including the following:

- A significant hydraulic gradient across the basins, depending on the hydraulic capacity of the connectivity that was created.
- The water in each basin has different water quality characteristics and each differs at different levels.
- Mixing the water would increase the loads in the less polluted water and the future water quality would be even more difficult to predict.

  This option does not appear to have any merits from a water quality perspective. Possible advantages of the benefit of scale were not considered as yet. It is not discussed further.

7 TOPIC 5: THE LOCATION OF THE PROPOSED ABSTRACTION POINTS IN THE STI

7.1 Description

The STI proposes using the following shafts for abstraction:

- Western Basin - Rand Uranium (RU) Shaft #8
- Central Basin - South West Vertical (SWV) at East Rand Proprietary Mines (ERPM)
- Eastern Basin - Grootvlei #3 Shaft. However, there are concerns about using the SWV shaft for the LTS and these are discussed below.

In the Western basin, the RU Shaft #8, which is to be used by the STI, has good connectivity to the mine void at several levels.

In the Central Basin, the SWV shaft only has connectivity to the mine void in the other compartments at about 1 080 m below surface. That connection is thought to be limited with the primary connection being a single haulage.

In the Eastern Basin, the STS proposed abstraction shaft is the Grootvlei No. 3 shaft. This shaft has limited connectivity with the Nigel Reef, but when used for pumping during mining in the past, maintained the required water levels across the entire basin. It does have significant ingress from the dolomitic aquifer which surrounds it.

7.2 Discussion

Given the time constraints it was necessary for the STI to use existing shafts which were expected to be stable in the long term. The STI considered various options and assessed the selected shafts, including camera surveys, prior to finalising the selection.

There is no reason to believe that abstraction at the selected points will not be able to meet the objectives of achieving or maintaining the ECL in the short- to medium-term. However, if a cone of drawdown develops locally around the pumping points, the water level could continue to rise beyond the radius of influence, possibly allowing the ECL to be breached at other points within the basin if there is insufficient freeboard. In the worst case scenario decant could occur.

The shafts selected for the Western and Eastern Basins are acceptable. In the Eastern basin, the Merrievale Shaft, at a lower elevation and further south than Grootvlei #3 may have a slight advantage, but would need to be investigated.

Identifying alternatives in the Central Basin, that could be shown to be beneficial in the long term, will require significant further investigations and an understanding of the complete LTS including treatment technologies and sites.

As noted above, the STI for the Central Basin is to pump from the SWV, which connects to the mine void at over 1 000 m below surface (mbs). There is a risk of haulage collapse and consequent loss of connectivity.

Another factor in selecting the shaft for abstraction is the expectation that if only water that is at a shallow depth can be abstracted; it will be of a better quality than water which has come from depth in the mine void. It is reported that the water in the voids is stratified, so pumping from a single point with connectivity only at great depths could induce upwelling of the poorer quality water from depth. In the Central Basin, water from the connected compartments will be pulled down to the haulage at 1 000 m, before being abstracted so “deep water” will be abstracted. There are thus concerns about the water quality in the Central Basin. Much more research, modelling, etc. would be required to assess the potential benefits and costs of optimising the dewatering strategy to selectively pump layers of better water quality. One option proposed is that if (in the Central Basin) water was only pumped from near the static water surface across a broader front (or wellfield) the quality, would be better than when water is drawn from a shaft which may only connect to the void at significant depth. Better estimates of this may actually only be possible after pumping has commenced and run from some time and monitoring of the water levels and water quality at monitoring points has provided better information for the modelling.

In the Central Basin, it has been suggested that old inclined shafts or a number of specially drilled and dispersed boreholes intercepting tunnels would provide better abstraction points with improved connectivity across the basin and with the opportunity to abstract water from near the surface. More research and studies would be required to evaluate these options. The old inclined shafts are likely to be less accessible and unstable and thus dangerous.

These alternatives are unlikely to have a lower capital cost, than the current STS, but may lead to a flatter hydraulic gradient. However, when abstracting water from dispersed points, it should be possible to only abstract water from just below the static water level, with benefits in terms of water quality.

7.3 Risks for the LTS

While there is a risk in the Western and Eastern Basins that there will be a core of drawdown. It is not expected to be significant or pose threat to meeting the objectives.

As discussed above, there is a risk, particularly in the Central Basin where the abstraction point is at the Eastern edge of the basin which basin stretches for about 50 km from East to

West of a significant line of drawdown. Although any abstraction point has an inherent risk that connectivity of tunnels and shafts within the void may in future be affected by rock falls, etc., the limited connectivity and reliance on a single haulage increases the risk significantly. It has been indicated and it is expected that pumping commences, the hydraulic gradient, which, in the Central Basin is currently horizontal for all practical purposes, will rise, from the abstraction point to the remainder of the basin. If the gradient rise is unacceptable, mitigation would be required. The hydraulic gradient will depend on the actual connectivity between the voids in the basins and this has not yet been reliably modeled.

When pumping commences the hydraulic gradient should continue to be monitored in all three basins.

7.4 Mitigation Options

No mitigation is required in the Western and Eastern Basins.

The following mitigation actions can be considered in any of the basins and implemented, if and when required.

- The tender documents issued by TCTA for construction in the Central Basin, envisage pumping from a level which is 224 m below the ECL to allow for future mining in that basin. If pumping to this level is implemented, it eliminates the risk of breaching the ECL, for as long as the dewatering and mining continue, unless there is a very substantial loss of connectivity across the basin.
- Pumping to the lowest water level achievable with the pumps at the installed level, which may be lower than the ECL.
- Lowering the pumps in the shaft(s) and pumping to lower the water level below ECL.
- Alternatively, if lowering the pumps does not achieve the objective it would be possible to establish one or more additional abstraction point(s) in the basin. The optimum location(s) and the alternatives of either treating near the new abstraction point(s) or conveying the water to the established treatment works would have to be investigated in more detail.

Because of the development around the Johannesburg Central Business District (CBD) alternative locations would probably have to be in the western part of the Central Basin.

If it can be shown that alternative abstraction points would have significant financial benefits with acceptable risks, additional or alternative abstraction points could be proposed.

The costs and potential benefits would require further investigations.

7.5 Implications

The main implication of the abstraction points is that alternatives should be investigated for the Central Basin to mitigate the risk of poor connectivity and poor water quality, as well as provide an abstraction point near the possible alternative treatment sites. See Section 13 – Topic 10.

7.6 Design

The investigation and design of alternative abstraction points, pumping equipment and the pipelines to the treatment works will be commenced in the LTS.

8 TOPIC 6: THE SELECTED PUMPS

8.1 Description

The STS proposes two duty pumps with – Variable Speed Drives (VSDs) to allow the pumping rate to be varied at each abstraction point. The pumps are sized to be able to pump the expected average flow when operated for 19 hours/day. The number of hours/day that the pumps run can be increased to 24 hours/day (approximately 20% increase), to maintain the required level or lower the level, (e.g. after periods of above average ingress or to reach a lower ECL).

One standby pump set has been ordered for the Central Basin, but not for the Western or Eastern Basins, comprising:

- Pump; including NRV and cooling shroud
- VSD
- Riser pipes
- Electrical cable (and winder)

The pumps for the Central Basin were supplied by Central Rand Gold (CRG) mine since they had already ordered them. The standby pumps will be provided on surface at each abstraction point. It is has been specified that a pump must be removable and the replacement operating within 24 hours.

The pumps for the other basins are being procured against a performance specification.

8.2 Discussion

The configuration of 2 duty pumps and one standby is accepted good practice.

From the information available and on the basis of the expected flows, water quality and ECL there are currently no grounds to propose a pumping or pumping configuration different from the recommended pumping configuration.

8.3 Risks for the LTS

The potential implication for the LTS (and STI) is that if a pump is out of commission for an extended period for maintenance, repair or refurbishment and one of the duty pumps then breaks down, the water level would rise since, there would then be no standby capacity. However with one pump operating full time, instead of 19 hours/day, the pumping rate would be 63% of design and the rate of rise would be relatively slow. The available freeboard will be checked to assess this risk.

The reliability of the power supply has still to be checked.

8.4 Mitigation Options

No mitigation options are proposed unless the power supply is considered inadequate.

Standby pumpsets will be provided in the LTS for the Western and Central Basins.

8.5 Implications

There are no implications for the LTS.

9 TOPIC 7: THE PROPOSED TREATMENT TECHNOLOGY

9.1 Description

The treatment plants for the STI are HDS plants comprising**:**

- Refurbishment of lime neutralisation and addition of two new modules at Rand Uranium in the Western Basin. Construction of new HDS plant at Rand Uranium has also been proposed.
- For the Central Basin a new HDS plant has been proposed to be constructed at ERPM SWV shaft.
- For the Eastern Basin a new HDS plant at Grootvlei mine shaft No. 3 has been proposed.

HDS technology is the conventional approach to neutralization of AMD. Unfortunately the HDS technology does not provide adequate metals or salinity reduction that is required to meet domestic or environmental quality requirements, as currently defined.

9.2 Discussion

The treatment technology being implemented by TCTA for the immediate and short-term measures has reportedly been primarily based on proven track record for the neutralization of AMD, rather than consideration of further treatment that may be required to meet long-term treated water quality objectives. It reflects a conservative approach and sound engineering under the time constraints.

TCTA have indicated that the proposed immediate and short-term treatment may not be able to consistently meet the quality of water to be delivered in terms of the DWA directive, since the directive qualities were not based on proven performance of the proposed High Density Sludge (HDS) technology on the AMD qualities that may actually arise.

The indicated treated water qualities that may be delivered by the HDS technology may be expected to cause impact on the receiving water systems, particularly the expectation that the residual Mn may be of 10 mg/ℓ, and not 3 mg/ℓ specified. This may be expected to subsequently precipitate out in the watercourse as a black sludge, (also effecting and oxygen demand on the watercourse), potential carry-through of fine particulate matter, high pH (being expected to be raised to pH 9.5 to reduce Fe and Mn content, but not re-adjusted), and residual high salinity, amongst other impacts.

9.3 Risks for the LTS

The technology proposed in the STS can be integrated into the LTS, may not necessarily be same that the LTS would have used as part of the reference design and costing for the LTS. Where it has been determined that there needs to be segregation of metal waste residues from gypsum waste residues to minimize waste disposal requirements and provide for potential beneficiation of the AMD waste residues. The current HDS technology produces a combined waste residue that is not considered suitable for beneficiation and may be classified as hazardous waste in terms of disposal requirements.

The indicated treated water qualities that may be delivered by the HDS technology create material challenges in further treating the water to meet potable, industrial or environmental quality requirements, particularly the high residual Manganese.

The LTS project cannot currently comment on potential environmental liabilities of the proposed immediate and short-term disposal routes in the absence of the necessary waste characterization, impact assessment and agreements in respect of such disposal.

9.4 Mitigation Options

The investigations of treatment technologies and the selection of a reference solution will take account of the HDS plants being implemented by the STI.

9.5 Implications

The type of sludge envisaged to be produced, and its disposal, appears to be acceptable in the short term, provided the authorities give permission for the proposed disposal route. However, the immediate and short-term disposal does not appear to be adequate for the long-term, creating material challenges for the long-term handling and disposal of the waste residues.

9.6 Design

The LTS may propose some refinements to the pre-treatment/neutralization process with respect to the characteristics of different waste products which may be produced rather than a single mixed waste stream, and enhancement of the pre-treatment performance to facilitate further treatment to potable, industrial or environmental quality requirements i.e. fine tuning of the process rather than a totally different design.

10 TOPIC 8: INFRASTRUCTURE TYPE AND LOCATION

10.1 Description

The treatment works in the Central and Eastern basins are located at the abstraction points. In the Western Basin it is located approximately 3 km south-west of the abstraction point.

A potable water supply is available or has been planned at each site.

Appropriate capacity power lines are available in all three basins, but connections need to be made. In the Eastern Basin an application from Eskom will be required.

Backup power supply from generators (1.3 kVA) is specified, but it is not clear for what specific purpose they will be installed.

10.2 Discussion

The locations for the treatment works in each basin require significant areas of accessible land. The proposed sites appear to have adequate space to accommodate the STI and LTS if necessary.

The design standards adopted in the STI are industry norms for this type of works and are based on conventional industry practice, appropriate as the first phase of the LTS.

Based on the STI being the first stage of the LTS, concrete rather than steel has been selected for construction of structures.

Concrete is acceptable and more durable than the steel. Given the corrosive conditions and the corrosion resistant materials and protection that would have been required for steel, the use of concrete is unlikely to be significantly different in capital cost.

Without performing a detailed design, capital cost and maintenance cost comparison between concrete and steel absolute values cannot be provided. However, steel could be more expensive in terms of life cycle cost, due to corrosion and maintenance requirements.

However, steel structures could possibly by dismantled and re-used in other locations if required.

10.3 Risks for the LTS

The biggest risk is that if the infrastructure is not properly operated and maintained its life will be shortened and expensive refurbishment will be required sooner than planned.

In addition, some of the infrastructure may have to be abandoned if it does not form part of the optimum solution.

10.4 Mitigation Options

It is recommended that the operation of the STI be outsourced, if appropriate, to the process owner or construction company to avoid a split in the liabilities if there are performance problems. This contract should continue until the operator of the LTS can take over.

10.5 Implications

No implications apart from possible constraints on the layout of the LTS if high cost items do not fit the optimum LTS.

10.6 Design

There are no suggestions for design changes.

11 TOPIC 9: POINTS FOR WATER DISCHARGE TO THE ENVIRONMENT

11.1 Description

The selected discharge points are:

- Western Basin - Tweelopies Spruit
- Central Basin - Elsburg Spruit
- Eastern Basin - Blesbokspruit upstream of the wetland

These points are all close to the Treatment Works with short pipelines.

11.2 Discussion

11.2.1 Western Basin

The discharge is into the seasonal Tweelopies Spruit and the constant flow and salinity will impact on the environment. However, the neutralized AMD from mining operations was discharged at this point for many years in the past so no new impacts are expected. An alternative would be to extend the discharge pipe by about 3.6 km to discharge into the Blougatspruit immediately downstream of the Percy Steward WWTW where the flow regime is already significantly modified by the effluent discharge. This would allow the Tweelopies Spruit to regain its seasonal flow characteristics although it is considered unlikely that the stream will rehabilitate itself without significant intervention to remove or at least loosen the hard salt deposits which have lined the stream bed.

11.2.2 Central Basin

The discharge into the Elsburg Spruit is the same point at which discharge of neutralized water from mine dewatering took place for many years. Re-introduction of these flows will have a negative impact on the environment. Discharging the water some 15 to 18 km further downstream, where a number of WWTWs already discharge their effluent, would have lesser impacts.

11.2.3 Eastern Basin

The discharge of saline water into the Blesbokspruit, adjacent to the abstraction shaft means that a significant volume of the ingress into the shaft will be the saline water. A proportion of the salts will be recirculated, thus slowing down the rate of flushing that will otherwise occur from ingress of water through the dolomite aquifer. Rather discharging the water some 10 km further downstream will keep the salts out of the wetland and will avoid this recirculating of the salts.

11.3 Risks for the LTS

The pipelines from the abstraction shaft to the treatment works give rise to the following risks, which would be present with any STS.:

- Risk of leaks, or blocking
- Significant maintenance costs
- A break in any of the pipelines will have an environmental impact but these are not likely.

11.4 Mitigation Options

These risks can only be mitigated through proper management, correct operation, effective maintenance and regular monitoring and inspections.

11.5 Implications

There are no significant implications.

If alternative discharge points are shown to be better for the LTS the infrastructure can easily be adapted or extended.

11.6 Design

The proximity of the treatment works to Rand Water reservoirs to facilitate the distribution of water for potable use if required seems adequate. The options for discharging to stream also seem adequate and can be easily changed if required.

12 TOPIC 10: WASTE DISCHARGE SITES

12.1 Description

The following waste disposal plans are proposed:

- Western Basin: Co-disposal in the West Wits Pit, which is 4.2 km from the treatment works. Capacity for 3 - 5 years.

- Central Basin: Co-disposal at ERGO via the Knights tailings operation. This is 3.6 km from the treatment works. The sludge would then be pumped through existing infrastructure to ERGO. The existing infrastructure will only be available tor 5 – 6 years.

  In the Central basin, the waste disposal site in the STI has a limited life of 3 to 5 years. A potential site for long term disposal at the ERGO facility, has been identified. This would entail a 22km pipeline. It is not included in the current TCTA tender or cost estimates.

- Eastern Basin: Disposal / co-disposal at the Ergo Brakpan Tailings facility, which is 15.3 km from the treatment works. Capacity for 30 + years.

12.2 Discussion

As a STI, the proposed waste discharge sites appear technically acceptable, but in the Western and Central Basins they have limited life. The environmental acceptability of the disposal sites, long-term environmental liabilities and responsibilities should be considered by the relevant authorities rather than the LTS team.

This aspect needs to be further investigated.

It was reported that adequate space would be provided at the proposed sites whilst at the same time flexible enough to accommodate future waste disposal requirements. This does not currently appear to be the case and the HDS sludge has poor consolidation characteristics. Whilst historically, and as proposed in the STI, it has been acceptable to dispose of HDS by discharge into tailings dam systems, the relative volumes allowed for the consolidation of the combined mass may be optimistic depending for how long each facility has to be used.

As a single waste sludge, as a homogenous waste stream with disposal to a dedicated waste facility, it would be classified as hazardous waste. Substantial surface area is required, which is not currently available.

The disposal of waste proposed in the STS for the Western Basin is not sustainable since the predicted life (capacity of the facilities) is 3 to 5 years.

In the Central Basin, a potential site for long term disposal at the ERGO Facility has been identified. Thus would entail a 22 km pipeline. It is not included in the current TCTA tender or cost estimates. Further work is required to develop a sustainable LTS.

The Eastern Basin site has capacity for many years, but with a finite life of perhaps 20 – 30 years.

12.3 Risks for the LTS

Waste management and disposal potentially poses the single biggest risk to the LTS. Whilst the intention of the STI was to provide a short term solution that would be sustainable when included in the LTS major gaps exist regarding waste management and disposal. These gaps include adequacy of disposal sites, clarification on waste characteristics and waste volumes.

There are operational risks but these are not different from those for any similar facility.

The long-term capacity for waste residue disposal is clearly not available in the immediate and Short-Term Solutions, or within the current land area allocated for the treatment plant in the Western and Central Basins.

The implication is that the LTS must identify suitable long term options for disposal for the sludge from the current neutralisation process or, if possible, options for a refined neutralisation process and use of some elements of the resultant segregated sludge and long term disposal of the decreased volume of the waste product.

Significant additional work is therefore required to address / mitigate the potential risks.

12.4 Mitigation Options

The only mitigation options are to pay careful attention to this aspect in the LTS.

12.5 Implications

There are no implications, and thus it will not be addressed in the LTS.

12.6 Design

The LTS must now investigate the options for either modification or disposal of the HDS or the long-term disposal of the HDS as produced from the STI.

The LTS ToR requires opportunities for the beneficiation of the waste to be assessed. The short term HDS technology does not allow for the segregation of primarily metal based sludge with resource recovery potential, from gypsum waste with re-use potential as building material additive etc. Further treatment of the HDS effluent to potable, industrial or environmental quality requirements will generate a saline waste stream which is not considered in the short-term strategy, and may be less readily acceptable for discharge to an existing tailings dam system, being water rather than solids. Further work is required to develop a sustainable LTS.

13 TOPIC 11: OPERATION OF THE STI

13.1 Description

The proposals for long term operation and maintenance of the infrastructure constructed under the STI must still be obtained and considered.

13.2 Discussion

The operation and maintenance of the STS is essential to deliver the water of the required quality, safely dispose of the waste and protect the asset.

13.3 Risks

The financial risk premium which the LTS bidders would allow to take over an existing asset will be affected by the standard of operation and maintenance.

Given the relative timing of the STS and LTS there are no alternatives.

13.4 Mitigation Options

If possible and appropriate, the responsibility for operation of the STI should remain with the designer/process supplier/contractor until the operator for the LTS can take over. This would limit the splitting of responsibilities and the accountability if the STI fails to deliver products that are within the specifications

13.5 Implications

If the STI is not properly operated and maintained, the LTS will have to restore the facility to the required standards.

If the STI has failed to meet the specifications for the water or waste, the LTS will have to manage the negative public perceptions and rectify any problems with the process or operations.

14 TOPIC 12: LAND AND TRANSFER ISSUES

14.1 Description

The STI has planned to utilise shafts and to be constructed on land currently owned by mines.

14.2 Discussion

The agreements for use of this land or plans for transfer of ownership are unknown and will need to be considered when the procurement documents are prepared for the LTS.

14.3 Risks of the LTS

These are unknown at this stage since they depend on the agreements between TCTA and the mines.

14.4 Mitigation Options

The agreements should be carefully reviewed by DWA Legal Services before they are signed.

14.5 Implications

Unknown at this stage.

15 TOPIC 13: PROCUREMENT ISSUES

15.1 Description

Whichever procurement strategy is selected and independent of any funding considerations for the LTS, the fact that there are now some works addressing AMD and there will soon be more works created based on the STI has implications for the LTS in terms of procurement, design and operational and risk transfer.

If the procurement strategy for the LTS is that Government will fund the capital required and that DWA will be the operator, then DWA will take on the solution design for the treatment plant, waste disposal and associated infrastructure and operational risk of the STI.

In the case of the LTS being either a DBOM or PPP solution, then the Private Party will be expected to take over, maintain and operate the STI infrastructure. The Private Party, in taking over an existing solution and operational infrastructure, will be constrained in the technical solution that it can offer and will be required to price any alternative solutions to use and the inherent latent defect risks.

15.2 Discussion

The positioning of the STI as the first phase of the LTS rather than planning the initial works as emergency holding works until the LTS could be implemented, significantly negatively impacts the risk profile of the LTS. Where a DBOM or PPP is selected as the method of procurement, the pricing of the risk is transparent and will be an item for discussion with a prospective private partner. The STI could, in the case where a private sector operator is contracted, result in the Government either having to provide Indemnities or in incurring araised cost due to the requirement that the Private Party takes over in its entirety the STI design, infrastructure and operations. Given that government self-insures, where government takes on the risk, the cost would be hidden and would only become visible at the time of a failure occurring. A failure would result in a significant negative and unplanned impact on the budget of the public entity responsible for the operations.

15.3 Risks for the LTS

The level of risk that Government will be able to transfer to a Private Party will also be constrained. The Private Party will be required to take over the abstraction solution and treatment technology solution designed into the STI, as well as the equipment selected and installed. It is possible that in the design process by either a public or private entity, in order to achieve a sustainable and efficient whole life solution, the STI infrastructure, or part thereof, might need to be abandoned or refurbished to suit the preferred LTS. A responsible party either in a government designed and operated solution, a DBOM or PPP will have to select the desalination technology downstream of the STI and the discharge of the “product” and the management of the wastes therefrom. It is likely that the responsible party will be locked into the STI design and operational framework.

In the case where there is a Private Party involved, it will take over these risks either through an appropriate pricing regime or through a lower price but with a Government provided indemnity for the potential latent defects of the equipment selected, installed, operated and maintained by TCTA and DWA. A Private Party might request an indemnity against a change in daily volume to be abstracted, outside the range allowed for in the contract, and the connectivity of the mining void to the abstraction point. This would depend on the nature of the contract secured with the Private Party.

National Treasury is generally not in favour of providing indemnities to the Private Sector and it would require that the Private Party price the risk of taking over the existing infrastructure with some transparent form of risk premium. With a transparent risk premium, government will be able to establish whether it thinks that the risk premium offered is value for money or whether it would rather offer an indemnity against that particular risk.

The Private Party will be required to take over the existing infrastructure and establish a sustainable solution. It would achieve this through minimising the impact of adverse consequences being felt from underground connectivity risk, equipment lifecycle risk, raw water quality risk and the above ground design and operational risk is mitigated. These risks will probably be mitigated through the installation of redundant infrastructure and the provision of a risk premium.

If a private sector partner route (design-build; DBOM; PPP) is followed it is possible that bidders may propose an alternative neutralization process, to suit their desalination technologies.

The practical AMD qualities and quantities that will be required to be treated have not been defined. Similarly, the practical performance of the proposed immediate and short-term measures has not been demonstrated to be able to comply with the DWA discharge quality directive, or any other discharge quality specification.

15.4 Mitigation Options

Mitigation of the risks inherent in the implementation of the LTS includes:

- Improved base information on the nature and performance of the underground voids;
- Clarity as to the possibilities for the disposal of waste;
- Clarity as to the off take opportunities and associated requirements for the treated water;
- Clarity as to the detail of the STI and the specifications for the design and installation of the infrastructure and equipment;

- Definition as to the operational and maintenance regimes;
- Certification that installation and operational and maintenance procedures have been followed;
- Clarity as to ownership and access of the required land;
- A procurement process that secures reliable, capable and competent private sector participants in the LTS. This applies to any private sector participants to the process;
- If government undertakes aspects of the LTS, that the resources allocated to the LTS are competent, capable and suitably mandated to effect the required activities;
- Appropriate transfer of risk to the party best able to manage such risk;
- Adequate funding of the capital and ongoing operations;

15.5 Implications

The procurement process to be used is based on a number of base assumptions. The decision process can start with a funding decision.

- Does Government require private Sector funding for the capital Works?
    - If Yes – PPP
    - If No – Government design and government operate, Design / build; DBOM; PPP

For an LTS with no Private Sector Funding

- Will government operate the facility
    - If Yes – Government Design and government operate LTS or Design build and government operate;
    - If No - Government Design and short term contracted out operator or Design build and short term contracted out operator, DBOM or PPP.

It should be noted that where government design or use a design / build construction solution and then either operate internally or secure the services of a short term operator, government retains the design risk and takes on a significant interface risk between the operator and the preceding contractor. In these scenarios, little risk transfer is achieved and the interface risk each time a new operator is secured increases. The management required by government for this option is not to be underestimated.

16 CONCLUSIONS

The pumping installations and abstraction points are the best that could be adopted by the STI in the time available. The HDS treatment works may not be ideal in terms of the full process, capacity or location for the LTS.

All the infrastructure being implemented by the STI could be incorporated in the LTS. Some elements, particularly the HDS plant will probably be refined or enhanced on the LTS, but those changes should not be considered now.

The greatest concern is the Central Basin where, if it is deemed to be prudent or economically preferable, to abstract water at additional locations, the treatment works and pumping capacity at the SWV will be oversized. It may be possible to relocate a pump, but the treatment works is fixed. Some mechanics and electrical equipment could be re-used.

In the Western and Eastern basins, the HDS plant may be oversized, depending on the treatment process for desalination in the LTS, but the implications in terms of cost are limited. If a tunnel option proves viable in any of the basins, the pumps may or may not be required, in such a scenario the STI HDS plant is unlikely to be incorporated in the LTS.

17 REFERENCES

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Feasibility Study for the Long Term Solutions – Pre-Feasibility Stage Reports:

- Report on Status of Available Information
- Legal Considerations for Apportionment of Liabilities
- Alternative Approaches for Apportioning Liabilities
- Pre-Feasibility Report on the Long-Term Solution
- Report on Current Status of Management of AMD
- Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids
- Report on Options for Use, Discharge or Disposal of Water and Waste
- Report on Treatment Technology Options