DIGBY WELLS ENVIRONMENTAL

FINAL SCOPING REPORT FOR THE IMMEDIATE AND SHORT TERM INTERVENTIONS FOR THE TREATMENT OF ACID MINE DRAINAGE (AMD) IN THE WESTERN, CENTRAL AND EASTERN BASINS OF THE WITWATERSRAND GOLD FIELDS

DEA Ref #: 12/1220/2403

TRANS-CALEDON TUNNEL AUTHORITY (TCTA)

NOVEMBER 2012

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This document has been prepared by **Digby Wells Environmental**.

Report Title: **Final Scoping Report for the Immediate and Short Term Interventions for the Treatment of Acid Mine Drainage (AMD) in the Western, Central and Eastern Basins of the Witwatersrand Gold Fields**

Project Number: **BKS1310**

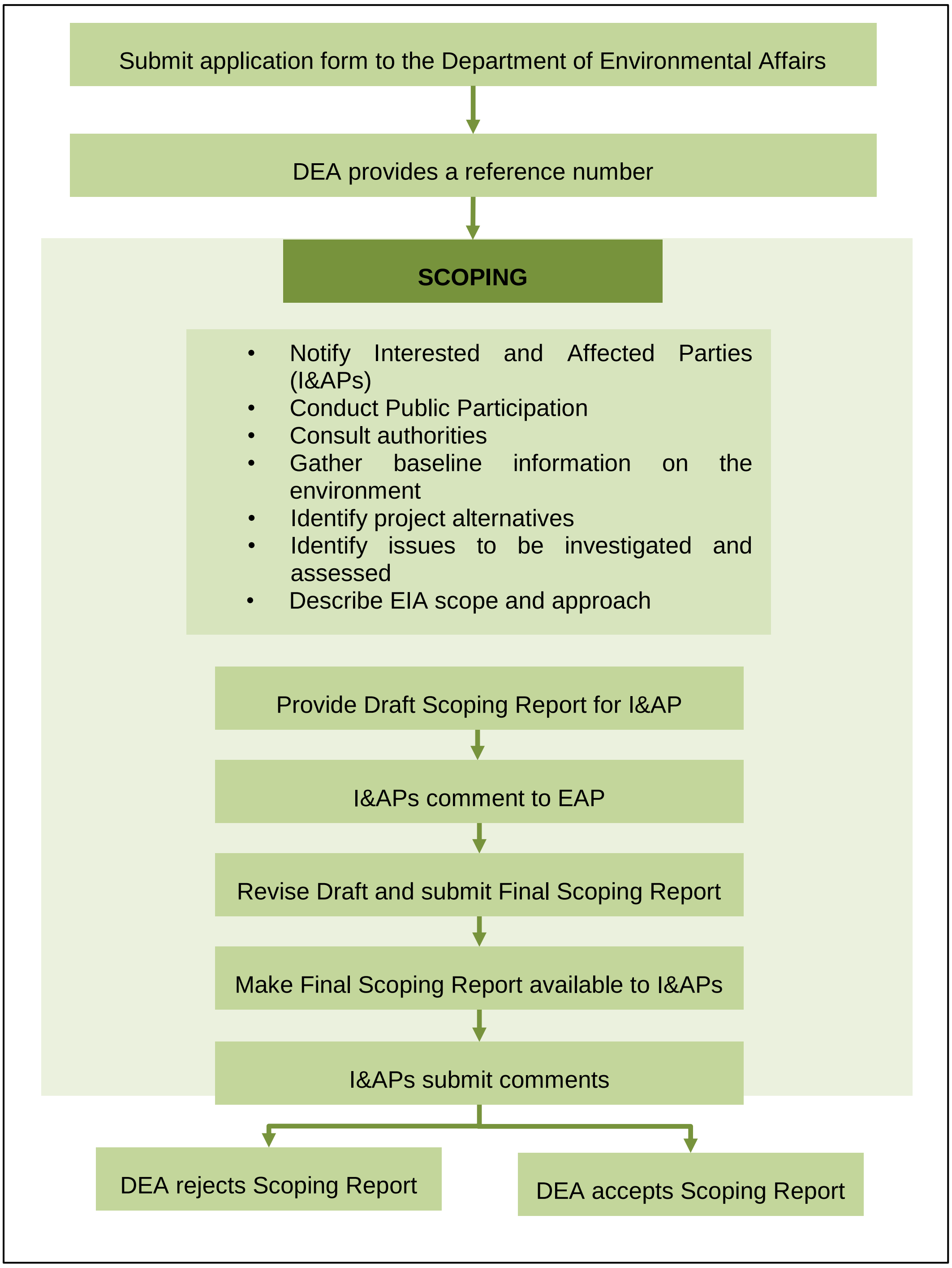
Name	Responsibility	Signature	Date
Grant Beringer	Report Compiler		07 August 2012
Graham Trusler	Report Reviewer		07 August 2012

EXECUTIVE SUMMARY

Digby Wells Environmental (Digby Wells) was appointed by The Trans-Caledon Tunnel Authority (TCTA) to conduct the Environmental Impact Assessment (EIA) process for the immediate and short term interventions for the treatment of Acid Mine Drainage (AMD) in the Witwatersrand Gold Fields in Gauteng, South Africa.

The EIA is considered a tool with which to manage the environment. The completion of an EIA is a regulatory requirement in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) and the EIA process is regulated in terms of the GN Regulations 543 to 546 (18 June 2010) (“EIA Regulations”). The overarching purpose of the EIA process is to determine, assess and evaluate the consequences (positive and negative) of a proposed development, activity or project.

This Final Scoping Report forms part of the EIA process and aims to identify those environmental issues and concerns that require investigation as well as determine feasible alternatives. This information is then used to determine the scope for the EIA. During the scoping phase those persons interested or affected by the project were informed of the project as well as provided the opportunity to provide their input in terms of issues and concerns they may have.



PROJECT OVERVIEW

Gold mining has occurred in the Witwatersrand for more than 120 years. During the underground mining operations, water was pumped to the surface to enable mining to take place. As mining stopped the pumping of underground water ceased and the mine voids started filling with water. The sulphide minerals in the rocks were exposed to water and oxygen, which resulted in AMD forming. The mining voids, thus, progressively filled with acidic water that contained heavy metals and started to decant on surface in September 2002 in the Western Basin at Randfontein.

This Scoping Report deals with the two main aspects of the proposed project. The first is the immediate intervention, whereby the existing Rand Uranium water treatment plant will be refurbished and upgraded to treat the water currently decanting from the Western Basin.

The second and more detailed aspect of the project is the construction and operation of the proposed short term intervention. This entails the construction of three new High Density Sludge (HDS) treatment plants. Water will be abstracted from existing shafts in the three basins, before being treated in the HDS plants. The neutralised water will then be discharged into streams within close proximity to the plant infrastructure.

The water will be abstracted such that a level is maintained in the old workings where it is prevented from affecting any infrastructure or aquifers. This level is called the Environmental Critical Level (ECL). For the Western Basin it will mean that the water table will be lowered from where it is currently discharging on surface to the ECL and for the Central and Eastern Basins it means that the water level will be intercepted and prevented from rising above these levels.

These interventions are considered as the first phases of the long term intervention for the mitigation of AMD. The focus of this Scoping Report is on the immediate and short term interventions for the Western, Central and Eastern Basins, which is holistically referred to as the “Witwatersrand Gold Fields AMD Project” (herewith referred to as the Witwatersrand AMD Project).

Why the need for the Project?

In April 2011, the Department of Water Affairs (DWA) instructed the TCTA to act as the agent for the design and implementation of the short term measures to manage and control AMD in the Western, Central and Eastern Basins of the Witwatersrand Gold Fields.

The overall aim of the immediate and short term interventions is to treat the mine water to a level that it can be discharged to the environment, with tolerable impacts on downstream water users. This requires neutralisation of the acidic mine water and precipitation and removal of heavy metals.

What happens if we do nothing?

If nothing is done, AMD will continue to decant from the Western basin and the water will rise in the Central and Eastern Basins until there is a discharge on surface. This water will contain a high level of dissolved salts, be acidic and contain a number of heavy metals and will affect the natural environment significantly in the vicinity of the discharges and possibly over a large area downstream.

Is this all that is required?

Although the proposed project will treat the water to a level where it will no longer be acidic and where most of the dissolved salts and the heavy metals have been removed, it is still however not suitable for human consumption, but possibly for some industrial uses. The discharge of the water into public streams will affect water quality downstream and the exact effect of this will need to be investigated. During operation the mines were treating and discharging water in a similar fashion to what is being proposed. The river courses will thus be affected in a similar fashion to what was the case when the mines were in operation.

There is the possibility of treating this water further to allow for more uses but this is the subject of further investigations which have been commissioned by the DWA and is not part of this project. The current project is seen as first step of any long term treatment solution to the AMD problem on the Witwatersrand.

The Inter-Ministerial Committee Task Team of Experts recommended that the direct consumptive use of the neutralised water must be investigated as well as the desalination and sale of the water to local users. They considered the proposed solution as part of a process to get to the final solution.

PROJECT DETAILS

The proposed Witwatersrand AMD project deals with the short term interventions as proposed by the Inter-Ministerial Committee Task Team of Experts.

For the short term interventions, new water treatment plants will be constructed in three areas:

- The Randfontein Estates area (Western Basin);
- The East Rand Proprietary Mines (ERPM) South West Vertical Shaft area (Central Basin); and
- The Grootvlei Mine Shaft No.3 area (Eastern Basin).

The infrastructure associated with these areas will consist of:

- Pumps and associated infrastructure at existing shafts (for the abstraction of AMD);
- HDS treatment plants being constructed at each basin (for the neutralisation of AMD);
- Pipelines to various streams (for the discharge of water into the Tweelopiespruit, Elsburgspruit and Blesbokspruit);
- Pipeline construction to sludge disposal areas (sludge disposal); and
- Roads and areas used for transportation and access (servitudes).

The HDS treatment process is designed to neutralise the acidic mine water and allow for the precipitation and removal of heavy metals. The secondary aim is to precipitate some of the soluble salts such as sulphate as gypsum from the mine water, thereby, reducing the salt load to the catchments into which discharge will take place.

The treatment technology will be used for the short term intervention will involve the following:

- Oxidation by aeration;
- Pre-neutralisation and metals removal with limestone;
- Final neutralisation and metals removal with lime, produced by the slaking of quicklime; and
- Gypsum crystallisation and precipitation to remove excess sulphate from solution.

The water abstraction from the mine voids is planned such that the level will be drawn down below surface to a level called the ECL. This is a level whereby polluted water is not expected to influence other underground aquifers.

The treatment process produces a waste stream called sludge which contains the precipitated salts and the heavy metals which needs to be safely disposed of.

A summary of the short term intervention per basin is provided below. Visual presentations of these projects are contained in Table 1-1, Table 1-2 and Table 1-3.

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. For the first two to three years this water will be treated concurrently by the Rand Uranium treatment plant and the short term treatment plant. Thereafter, the ECL will be maintained by treating the water at the short term plant only, where pumping will be reduced to an average of 27 Ml/day (peak of 35 Ml/day);
- 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 about 1,8km east of the Germiston Central Business District (CBD) 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 1 467 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).

In order to meet the timing requirement in the Central Basin it may not be possible to complete the full EIA process prior to construction having to take place to install the pumping equipment to ensure the water level does not exceed the ECL.

Eastern Basin

The proposed Eastern Basin AMD water treatment plant will be situated at the Grootvlei Mine Shaft No. 3 about 4,6km east of the Springs CBD. The site is accessible via the R29 Ermelo Road and Grootvaly Road through the suburb of Casseldale. 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.

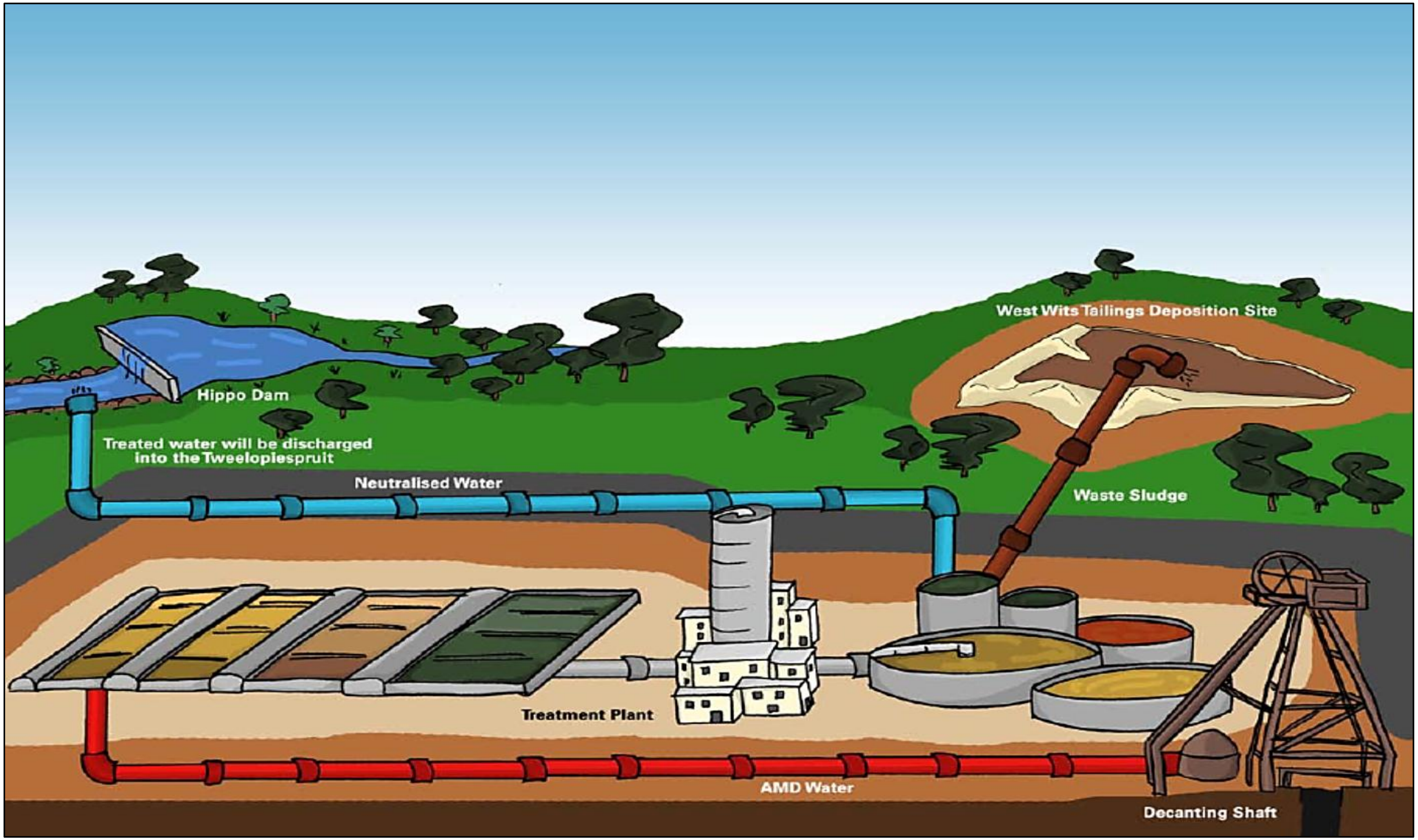


Table 1-1: Western Basin

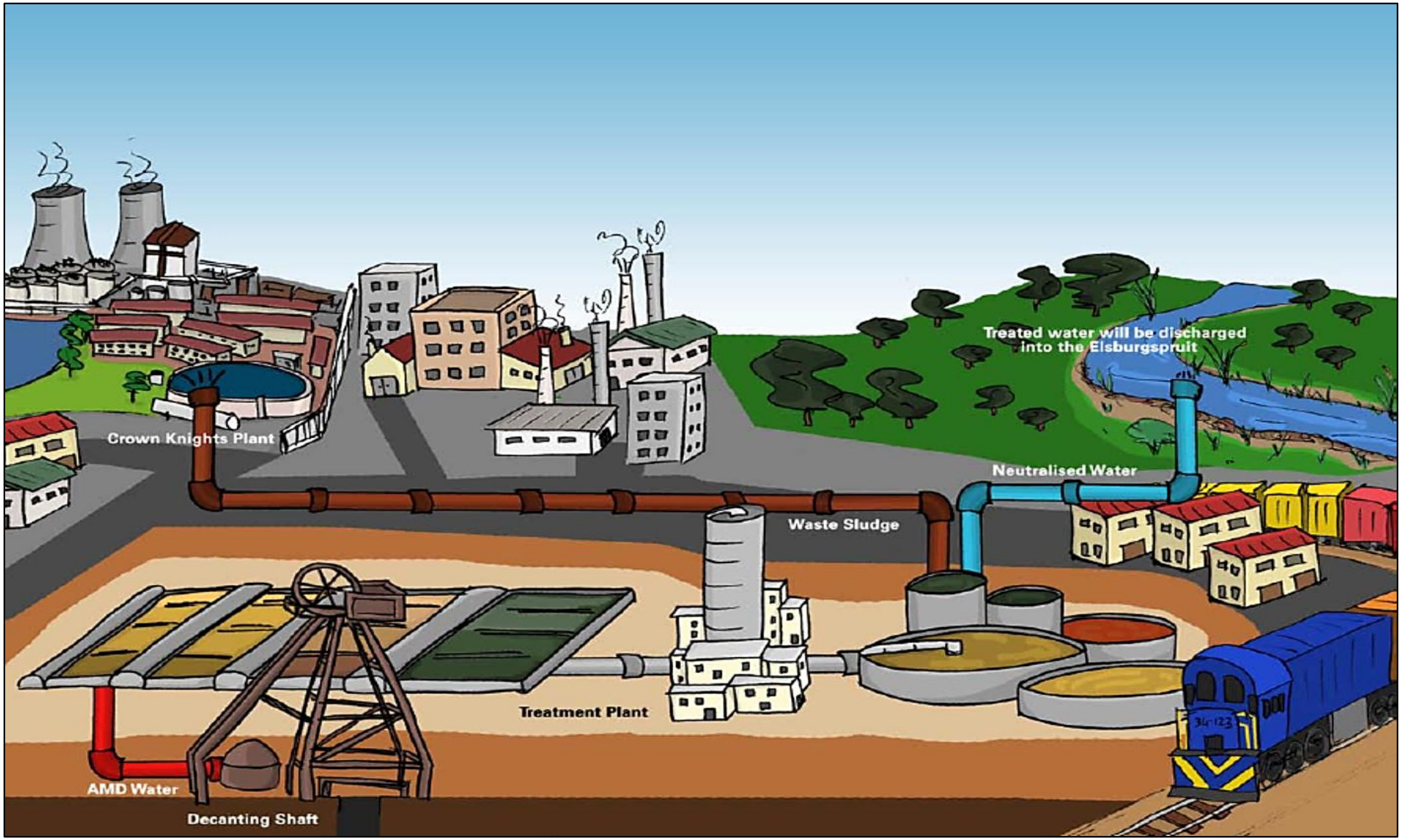


Table 1-2: Central Basin

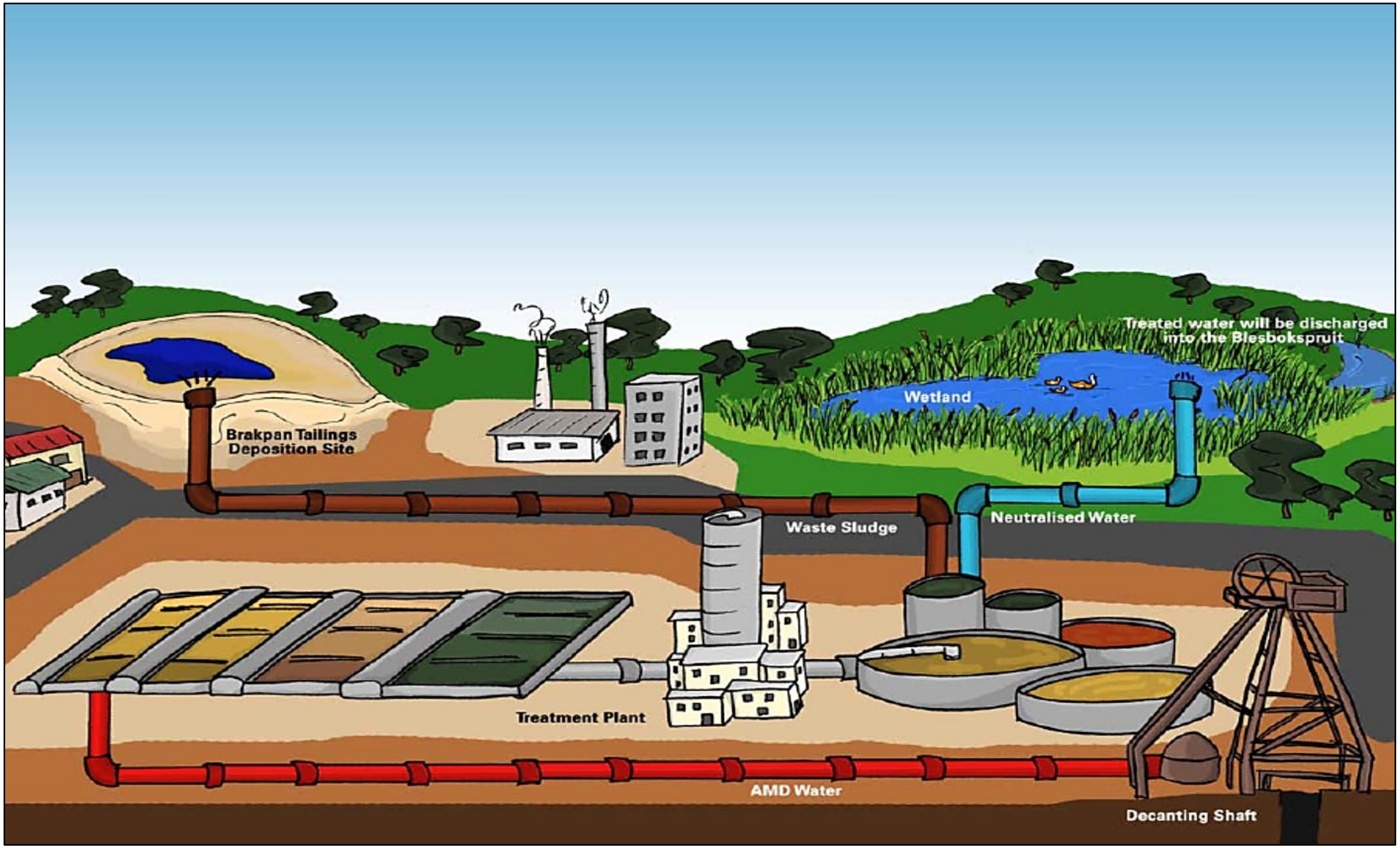


Table 1-3: Eastern Basin

PROJECT ALTERNATIVES

As part of the scoping phase, reasonable alternatives to the proposed activities were explored. The following alternatives were considered:

Treatment technology alternatives

The treatment technology selected for the short term intervention is neutralisation through the HDS treatment route. It has been chosen due to its large scale application around the world for problems of this nature. Alternatives within the process consist of the use of different neutralising agents. Other alkalis such as only lime, sodium carbonate, or sodium hydroxide could be used, however, the cost has precluded their use on a large scale for this type of application.

The main process alternative to be considered is the full scale processing or final treatment of AMD. This process would also involve the neutralisation of the AMD, but, as a second phase would include the desalinisation of the water, improving the quality of the water. This alternative was not considered for the short term intervention due to the following reasons:

- It is expensive and a mechanism must be found as to whom is going to pay for this treatment and how it is going to be done;
- Institutional arrangements have to be put in place to manage the operation of these facilities and the water resulting from these facilities;
- The construction takes time and something needs to be done now as a matter of urgency;
- The standards to which the water should be treated have not yet been decided. It could be to potable standards, industrial standards or for discharge into a stream; and
- Different technologies need to be considered for the different areas.

Sludge disposal alternatives

In addition to the options proposed, there may be alternatives to place the sludge into specially designed and sealed disposal facilities. These will have to be designed such that they can be sustainably closed after operation.

There is also the opportunity to place the sludge on top of unused tailings facilities as this will ensure that geotechnical conditions are understood and that no additional surface area is disturbed.

Abstraction alternatives

A possible alternative in the Central Basin is to place the pumps or abstraction point nearer the outcrop area to ensure that water quality improves more quickly over time and to prevent highly saline water being drawn from the deeper workings over time. Different shafts could also be considered based on the fact that some shaft areas may have more functioning infrastructure than others

Treated water discharge alternatives

An alternative to the discharge of the treated water is to sell the water to users rather than allowing it to discharge directly into the water courses. Whilst the water could be used for reclamation of tailings materials or pumped to other catchments for use such as in the platinum mines, it is difficult to determine the needs of these mines and the volumes they would require. In Addition, the economic cycles of projects often do not correspond with the need to discharge.

An alternative to the proposed discharge point in the Western Basin, the Tweelopiespruit, would be to discharge the treated water into the Wonderfonteinspruit. The treated water would, therefore, enter the Vaal Catchment rather than the Crocodile system. A possible reason as to why this alternative is less suitable is due to the fact that even further salt loads would be introduced into the Vaal River system. An additional concern to this alternative is that some of the water from the Loopspruit may re-enter the groundwater regime over dolomitic ground. There is a pipeline which has been constructed over the dolomitic ground which may not have sufficient capacity to accommodate the neutralised water from the Western Basin.

ISSUES AND COMMENTS

During the scoping phase a number of issues and concerns were raised. The key issues and concerns and their associated responses have been summarised in the table below:

Issue	Response
The importance for the EIA to investigate alternatives particularly the no-go alternative	The EIA will investigate alternatives including the no-go option.
How and who will finance the interventions?	The immediate and short term interventions capital investment for the infrastructure will be funded by the government. The intention of government is that capital cost incurred will eventually be recovered from the water users and the mines. One of the objectives of the long term solution is to determine a model for financial recovery.
The impact of the project on downstream users.	This will be investigated in the EIA
Water quality issues particularly the release of water containing high salts.	This will be investigated in the EIA
Water quantity issues relating to the release of additional water down the streams	The impact of the additional water being released will be investigated in the EIA.

Issue	Response
The reasons why the project is not going the full treatment route including desalinisation.	The reason that desalination is not implemented within the current phase is to allow the correct selection of operation and treatment to be determined by the Long Term solution feasibility study.
The projects impact on the Vaal River and the potential of the project causing the Vaal river going into deficit.	Aurecon is looking at the long term solution which will also address the issue of the Vaal River going into deficit.
The impact of the project on groundwater.	The EIA will investigate the full extent of impact on the groundwater system.
The impact of the project on the ecology of the rivers.	The EIA will investigate the impact on the ecology and will suggest mitigation measure
The impact of the project on human and animal health.	This will be investigated in the EIA.
Public Participation ensuring that the project is made known to as many people as possible particularly the disadvantaged.	The EIA has been well advertised as per the public participation process. Meetings targeting the disadvantaged will be undertaken.
Due legal processes to be followed particularly around the use of section 24G.	TCTA has taken a decision to proceed with the EIA process and then apply for a section 24 G if required. If TCTA wait for authorisations, the ECL will be breached and decant in the Central and Eastern Basin will occur.
Treatment technologies and particularly alternative technologies.	Alternatives will be investigated as part of the EIA.
Sludge disposal sites and possible groundwater contamination.	Sludge disposal options will be investigated in the EIA.

POTENTIAL IMPACTS

The scoping phase has allowed for the identification of potential impacts associated with the proposed project. As part of the EIA these impacts will be assessed and evaluated to determine their significance. These potential impacts are listed below:

- Surface water quality:
  - Deteriorating water quality in streams affecting beneficial water uses;

  - Elevated sulphate levels affecting human and animal health;
  - Elevated temperature, conductivity, pH, O_2 content, sulphates, heavy metals and micro-organisms in impacted streams. Many of these variables hold direct health and other water use impacts, as well as promoting damaging sludge blankets; and
  - Reduction in yield of the Vaal River system due to elevated salt load entering the Vaal Barrage.
- Surface water quantity:
  - The inundation of riparian property (incl. informal areas, footpaths, access roads, etc.);
  - Impacts on low level bridges, structures, etc., affecting level of service and stability of the structures;
  - Effect on stability of farm dams, and especially spillways due to the potential of persistent spilling due to higher base flows;
  - Channel stability, especially in upper reaches of study area. Higher base flows may change the dynamics of the receiving stream and river channels; and
  - Potential movement of contaminated sediments. Especially near existing decant points and the proposed discharge points, the local sediments either have or may receive contaminants from the process. These may move further downstream under the new base flow regimes proposed.
- Geohydrology:
  - Potential reduction in groundwater quantities relied upon by water users, through the abstraction of AMD;
  - Reducing pressure through dewatering in mine voids and dolomite solution cavities – potential for collapse (geology instability);
  - Seepage of discharged water back into groundwater environment through rivers and streams. This may have a quality impact due to high salt load and waste of energy due to the recycling of water;
  - Seepage of sludge and TSF mixture into groundwater environment causing a quality impact; and
  - Deposition of sludge into Wes Wits Pit might have negative impact on water quality.
- Air quality:
  - Elevated concentration of PM10, PM2.5 particulate matter in the atmosphere due to the deposition of the sludge on tailings facilities.

- Archaeology and heritage:
  - May cause alteration, damage to or destruction of historical buildings and structures older than 60 years;
  - Potential increases in water flow due to discharge may impact on heritage resources that could occur downstream and near river banks;
  - Potential increases in water flow due to discharge may impact on intangible heritage aspects such as baptism sites located in or near river; and
  - Increased flow into the Tweelopiespruit may change aspects of the Cradle of Humankind World Heritage Site (COH WHS).
- Human health:
  - Possible health impacts associated with the exposure to surface water discharge as it may contain radionuclides, heavy metals and high salt loads.
- Socio- economic:
  - People in the surrounding communities are hired during the construction and operational phases of the project;
  - Increased expenditure on the short term solution which is funded by the government; and
  - Economic and health impacts may result on downstream water users.
- Agriculture:
  - Should the discharged water be used for irrigation or livestock watering the potential to affect agriculture exists.
- Ecology:
  - The water levels of the rivers and streams receiving discharged water will rise, possibly inundating previously seasonally wet areas and temporarily flooding areas that previously remained dry throughout the wet season;
  - The ecological flows may be affected in that the base flows will be higher year round as a result of the proposed discharge; and
  - The treated water may potentially impact the water quality of the rivers and in turn the functioning of ecological systems.

SPECIALIST STUDIES REQUIRED

In order to investigate and assess the impacts of the proposed AMD project the following specialist studies have been proposed for the EIA phase:

- Surface water assessment, including:

  - Surface water quality; and
  - Surface water quantity
- Characterisation of the social environment;
- Radiation study;
- Community Health Impact Assessment (CHIA);
- Ecological assessment, including:
  - Wetland investigation;
  - Fauna & flora assessment; and
  - Aquatic assessment.
- Geohydrological assessment;
- Archaeology and heritage assessment;
- Economic analysis;
- Agricultural assessment;
- Technology assessment;
- Air quality assessment.

INFORMATION REQUIRED TO BE INCLUDED IN A SCOPING REPORT IN TERMS OF GN REGULATION 543 OF THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (ACT 107 OF 1998)

CONTENT	REFERENCE
a) Details of – (i) the EAP who prepared the report; and (ii) the expertise of the EAP to carry out scoping procedures.	Chapter 3 – Section 3.1 & 3.2
b) Description of the proposed activity	Chapter 4
c) A description of any feasible and reasonable alternatives that have been identified	Chapter 5
d) A description of the property on which the activity is to be undertaken and the location of the activity on the property, or if it is – (i) A linear activity, a description of the route of the activity; or (ii) An ocean-based activity, the coordinates where the activity is to be undertaken.	Chapter 4 – Section 4.5
e) A description of the environment that may be affected by the activity and the manner in which the activity may affect the environment.	Chapter 6
f) An identification of all legislation and guidelines that have been considered in the preparation of the scoping report.	Chapter 2
g) A description of environmental issues and potential impacts, including cumulative impacts that have been identified.	Chapter 8
h) Details of the Public Participation Process conducted in terms of regulation 27(a), including – (i) The steps that were taken to notify potentially interested and affected parties of the application (ii) Proof that notice boards, advertisements and notices notifying potentially interested and affected parties of the application have been displayed, placed or given. (iii) A list of all persons or organisations that were identified and registered in terms of Regulation 55 as interested and affected parties in relation to the application (iv) A summary of the issues raised by interested and affected parties, the date of receipt of and the response of the EAP to those issues	Chapter 7
i) A description of the need and desirability of the proposed activity.	Chapter 4 – 4.2

CONTENT	REFERENCE
j) A description of identified potential alternatives to the proposed activity, including advantages and disadvantages that the proposed activity or alternatives may have on the environment and the community that may be affected by the activity	Chapter 5
k) Copies of any representations any comments received in connection with the application or the scoping report from interested and affected parties.	Chapter 7 & Appendix L
l) Copies of the minutes of any meetings held by the EAP with interested and affected parties and other role players which record the views of the participants.	Chapter 7 & Appendix L
m) Any responses by the EAP to those representations and comments and views.	Appendix L
n) A plan of study for the environmental impact assessment which sets out the proposed approach to the environmental impact assessment of the application, which must include – (i) A description of the tasks that will be undertaken as part of the environmental impact assessment process, including any specialist reports or specialised processes and the manner in which such tasks will be undertaken (ii) An indication of the stages at which the competent authority will be consulted (iii) A description of the proposed method of assessing the environmental issues and alternatives, including the option of not proceeding with the activity; and (iv) Particulars of the public participation process that will be conducted during the environmental impact assessment process.	Chapter 9
o) Any specific information required by the competent authority.	
p) Any other matters required in terms of Section 24(4)(a) and (b) of the Act.	

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ACRONYMS

ACRONYMS	DESCRIPTION
AMD	Acid Mine Drainage
ASAPA	Association of Southern African Professional Archaeologists
BID	Background Information Document
CARA	Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)
CRR	Comments and Response Report
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
Digby Wells	Digby Wells Environmental
DWA	Department of Water Affairs
EAP	Environmental Assessment Practitioner
ECL	Environmental Critical Level
EIA	Environmental Impact Assessment
EIA Regulations	GN Regulations 543 to 546 (18 June 2010)
EMP	Environmental Management Plan
HDS	High Density Sludge
I&AP	Interested and Affected Party
IMC	Inter-Ministerial Committee
mamsl	Meters above mean sea level
MPRDA	Minerals and Petroleum Resources Development Act (Act No. 28 of 2002)
NEMAQA	National Environmental Management: Air Quality Act (Act No.39 of 2004)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)

ACRONYMS	DESCRIPTION
NEMBA	National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)
NID	Notice of Intent to Develop
NHRA	National Heritage Resources Act, 1999 (Act No. 25 of 1999)
NORM	Naturally Occurring Radioactive Materials
NWA	National Water Act, 1998 (Act No. 36 of 1998)
PPP	Public Participation Process
SAHRA	South African Heritage Resources Agency
TSF	Tailings Storage Facility
ToR	Terms of Reference
TCTA	Trans-Caledon Tunnel Authority
WMA	Water Management Area
WWP	West Wits Pits

1 INTRODUCTION

1.1 Project overview

Digby Wells Environmental (Digby Wells) was appointed by The Trans-Caledon Tunnel Authority (TCTA) to conduct the Environmental Impact Assessment (EIA) process, which includes the compilation of an EIA and Scoping Report, for the immediate and short term interventions for the treatment of Acid Mine Drainage (AMD) in the Western, Central and Eastern Basins of the Witwatersrand Gold Fields, situated in the Gauteng Province, South Africa, as shown in Plan 1(Appendix A).

TCTA was instructed by the National Government, through the Minister of Water and Environmental Affairs to implement the short term interventions to treat AMD in the Western, Central and Eastern Basins. There are two main components to the proposed project. Firstly, an immediate intervention to neutralise acid water already decanting from the Western Basin at the current Rand Uranium treatment plant, and secondly, a short term intervention which entails the pumping of water from the Western, Central and Eastern Basins to reduce and prevent surface decant and to neutralise this water in newly constructed High Density Sludge (HDS) treatment plants, before release into the environment. These interventions are considered as the first phases of the long term intervention for the mitigation of AMD. The focus of this Scoping Report is on the immediate and short term interventions for the Western, Central and Eastern Basins, which is holistically referred to as the “Witwatersrand Gold Fields AMD Project” (herewith referred to as the Witwatersrand AMD Project).

1.2 Acid Mine Drainage

AMD is acidic water (pH <5.0), containing iron, sulphate and other metals, that forms under natural conditions when geologic strata containing sulphides are exposed to the atmosphere or oxidising environments. Many metallic ores contain significant amounts of sulphide minerals, particularly pyrite (FeS2). Mining often exposes large amounts of pyrite and other sulphide minerals to the effects of water and oxygen in the old workings, and from waste rock and tailings are on surface. The mining 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.

In the case of gold mining on the Witwatersrand numerous large old mining areas have become connected thus allowing water to migrate from one mine to another.

Although a host of chemical processes contribute to acid mine drainage, pyrite oxidation is by far the greatest contributor. A general equation for this process is:

$$\mathbf{4FeS_2(s) + 14O_2(g) + 4H_2O \rightarrow 4Fe^{2+(}aq) + 8SO_4^{2-(}aq) + 8H^{+}(aq)}$$

Oxidation of the ferrous ion to ferric ion occurs more slowly at lower pH values:

$4Fe^{2+(}aq) + O^{2}(g) + 4H+(aq) \rightarrow 4Fe^{3+(}aq) + 2H_2O\ (l)$

Ferric iron precipitates as ferric hydroxide, producing further acid:

$4Fe^{3+(}aq) + 12H_2O(l) \rightarrow 4Fe(OH)_3(s) + 12H^{+}(aq)$

(Coetzee et al., 2007, IMC)

The net effect of these reactions is to release H^+, which lowers the pH and maintains the solubility of the ferric ion.

1.3 Project background

After more than 120 years of deep level gold mining on the Witwatersrand, mining and dewatering has stopped in most areas due to the exhaustion of gold resources or due to the uneconomic nature of the remaining reserves. The cessation of dewatering has resulted in progressive flooding of the mine voids since 1997. In the Western Basin, the voids filled with water and the reaction between the rock surface and the water resulted in heavy metals dissolving and becoming suspended in the water reducing the pH and making the water acidic. Decant started from an old shaft on the Rand Uranium property in the Randfontein area of the West Rand in September 2002. The Central and Eastern Basins will decant in a similar uncontrolled fashion in the future unless there is some intervention.

In 2010, Cabinet appointed an Inter-Ministerial Committee (IMC) to address the serious environmental and social challenges posed by AMD in the Witwatersrand Gold Fields area. The IMC tasked a Technical Committee to investigate the AMD issues. The Technical Committee subsequently appointed a team of experts, who developed and presented a draft report on AMD to Cabinet on 9 February 2011. The team of experts recommended that AMD intervention measures be undertaken in the Western, Central and Eastern Basins as a matter of urgency. This involved a short term intervention, where AMD is pumped from the Western, Central and Eastern Basins to prevent surface decant and to neutralise this water before release into the environment.

The Due Diligence study conducted by BKS included an immediate intervention to neutralise acid water already decanting from the Western Basin.

The team of experts believed that there could be risks due to the flooding of the mines with regard to:

- The contamination of shallow groundwater resources required for agricultural use and human consumption;
- Geotechnical impacts such as the flooding of underground infrastructure in areas where water rises near to urban areas; and
- Increased seismic activity which could have a moderate localised effect on property and infrastructure.

They saw risks due to the uncontrolled decant of AMD to the environment as:

- Serious negative ecological impacts;
- Regional impacts on major river systems; and
- Localised flooding in low-lying areas.

They recommended a generic approach to managing the priority areas:

- Decant prevention and management (by keeping the water in the voids at or below the Environmental Critical Level (ECL) by pumping);
- Ingress control (reducing the rate of flooding and the eventual decant volume); and
- Water quality management (treating water through a number of different ways).

The ECL recommended by the Team of Experts were as follows:

- Western Basin 1530 mamsl;
- Central Basin 1503 mamsl; and
- Eastern Basin 1150 mamsl.[1]

The IMC also stated that the direct consumptive use of the neutralised water must be investigated as well as the desalination and sale of the water to local users. They did not decide on any method for fully recovering the costs associated with AMD treatment and thus recommended that the neutralisation option be applied as this would return the situation to a position where it was prior to the cessation of pumping and treatment by the mining companies.

The Minister of Water and Environmental Affairs used this advice when she tasked TCTA to implement the solutions proposed by the IMC Team of Experts. The report, however, recognised that although the short term interventions will produce conditions similar to the status quo during periods of active mining, these interventions are merely the initial phase of a long term sustainable solution to the problem of AMD. The short term project will neutralise the AMD, remove heavy metals and a large portion of the dissolved salts.

The long term intervention, which could include possible further desalinisation, must be investigated and a study to this effect has been commissioned by the Department of Water Affairs (DWA). The long term intervention, however, does not form part of the scope of the EIA. The immediate and short term interventions are to be the first phases of the long term intervention for AMD and are the subject of this Scoping Report.

As the treatment of AMD in the Western Basin and the prevention of uncontrolled AMD decant from the other mining basins is considered of national importance, DWA have subsequently issued TCTA with a directive, attached as Appendix B, to act as the Agent to

[1] These were amended during the Due Diligence conducted by BKS.

plan, design and implement the immediate and short term interventions to manage and control AMD in the Western, Central and Eastern Basins of the Witwatersrand Gold Fields.

Based on the findings of the IMC Report, the Minister of Water and Environmental Affairs, directed TCTA to implement the recommendations made. TCTA contracted BKS to complete a Due Diligence study on the proposed recommendations. This was completed in August 2011. BKS's scope of work can be divided into five tasks:

- Task 1: A due diligence review of the Inter-Ministerial Committee Report (as provided by TCTA) and the recommendation of a solution for each of the mining basins;
- Task 2: Development and production of documents supporting the Integrated Regulatory Process for all basins;
- Task 3: Development and production of engineering design and tender documents that will be used for competitive procurement of a competent contractor(s) combined with detailed engineering design of the agreed and approved solutions for each of the mining basins, complete with construction drawings;
- Task 4: Monitoring of the Contractor's activities and commissioning of the works; and
- Task 5: Monitoring of the works during the defects liability period, taking corrective actions if required, and the provision of formal operation and maintenance manuals as well as close-out reports.

The outcomes and recommendations arising from Task 1: Due Diligence, are described below.

BKS recommended that the following AMD treatment technology and chemical reagent combination be used for the treatment of the Witwatersrand Gold Fields AMD:

- Oxidation by aeration;
- Pre-neutralisation and metals removal with limestone;
- Final neutralisation and metals removal with lime, produced by the slaking of quicklime; and
- Gypsum crystallisation to remove excess sulphate from solution.

The proposed AMD treatment plants would be based on the proven and reliable HDS process with optimisation related to the use of limestone (mainly developed by the CSIR) incorporated into the final treatment process configurations.

They proposed that the following Immediate AMD mitigation measures are implemented the Western Basin:

- 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; and
- The potential AMD treatment capacity, including the existing single operational treatment train is estimated to be 26-32 Ml per day.

As part of the Due Diligence, BKS, in conjunction with the Council of Geoscience, calculated the ECLs For the three basins. The ECLs calculated and used for the purposes of this EIA are as follows:

- 1550 mamsl – Western Basin;
- 1467 mamsl – Central Basin; and
- 1 280 mamsl – Eastern Basin.

This means that the water level in the Western Basin will need to be lowered from its current level at surface to approximately 160 m below surface (Shaft No. 8). For the Central Basin it will mean building pumping facilities such that the water can be maintained at 150 m below surface (at the lowest lying shaft) and for the Eastern basin to keep the water table at 270 m below surface (at the lowest lying shaft).

Based on their due diligence investigation, BKS, made the following recommendations for the short term management of AMD:

- Western Basin:
  - Abstraction of AMD via installed pumps at Shaft No. 8 Shaft to achieve the ECL;
  - Construction 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, flowing to the Crocodile River; and
  - Construction of waste sludge disposal pumps / a pipeline to the CPS Pit and the West Wits Pit.
- Central Basin:
  - Abstraction of AMD via installed pumps in the South West Vertical (SWV) Shaft maintain the water level below the ECL level;
  - Construction of a new HDS plant at SWV Shaft;
  - Construction of a waste sludge pipeline to the DRD Gold Crown Knights Gold Plant; and
  - Construction of a treated water pipeline to a suitable discharge point on the Elsburgspruit.

- Eastern Basin:
  - Abstraction of AMD via installed pumps in Grootvlei No. 3 shaft to maintain the water level below the ECL level;
  - Construction of a new HDS treatment plant adjacent to the Grootvlei No. 3 shaft;
  - Construction of a waste sludge pipeline to the DRD Gold Daggafontein Gold Plant for co-disposal on the Daggafontein Tailings Storage Facility (TSF)[2]; and
  - Construction of a treated water pipeline to a suitable discharge point on the Blesbokspruit.

As part of the due diligence the capital and annual operating cost estimates for the AMD treatment plants for the three basins were calculated. These estimates are shown in Table 1-1 and Table 1-2.

Table 1-1: Capital costs for all three basins

Number	Description	Western Basin	Central Basin	Eastern Basin
1	AMD collection infrastructure	R 40,787,729	R 45,127,500	R 60,096,771
2	AMD treatment plant	R 73,255,525	R 90,631,838	R 108,010,007
3	Neutralised water discharge	R 1,316,400	R 1,172,400	R 1,622,400
4	Sludge handling and disposal	R 1,711,806	R 6,200,000	R 6,800,000
5	Earthworks and pipe work	R 31,008,353	R 46,196,290	R 28,480,441
6	Electrical control and instrumentation	R 25,960,790	R 23,735,832	R 30,856,582
7	Preliminaries and Generals	R 20,884,872	R 25,567,663	R 28,303,944
	Total	R 194,925,475	R 238,631,500	R 264,170,100
	Total (all basins)	R 697,727,075		

[2] This has been amended to include the Grootvlei and Brakpan TSFs.

Table 1-2: Operational costs for all three basins

Number	Description	Western Basin	Central Basin	Eastern Basin
1	O&M on CAPEX	R 3,600,100	R 4,128,600	R 4,571,500
2	Chemical costs	R 31,177,274	R 61,602,829	R 60,444,482
3	Electricity costs	R 13,527,200	R 15,146,600	R 15,520,700
	Total	R 48,304,574	R 80,878,029	R 80,536,682
	Total (all basins)	R 209,719,285		

The Due Diligence for the development and planning of short term AMD management and mitigation measures, was done within the context of accommodating the long term mine water reclamation and reuse from the respective mining basins. The selection of suitable AMD treatment plant sites, the choice of AMD neutralisation technology, the general configuration of infrastructure and pipeline routes and corridors were all undertaken to provide seamless integration with the long-term mine water management.

Based on the conclusions of the due diligence completed by BKS, Digby Wells Environmental was appointed by TCTA to undertake the EIA process for the immediate and short term interventions. Thus far, Digby Wells have announced the project to the public as well as conducted an internal risk assessment for the project, all of which form part of the Scoping Phase of the project. Digby Wells have also engaged with the authorities regarding the legal process to follow and provided Interested and Affected Parties (I&APs) the opportunity to comment on the proposed project.

It must be noted that since the drafting of the Due Diligence Report various changes in terms of project description and infrastructure have been made. This report, therefore, aims to provide the latest project details.

2 LEGISLATIVE REQUIREMENTS AND PLANNING CONTEXT

2.1 Legislative framework

The following legislation and guidelines are applicable to this project and will be considered during the EIA process for the proposed AMD treatment project.

2.1.1 Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996)

Section 24 of the Constitutional Act states that everyone has the right to an environment that is not harmful to their health or well-being and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures, that -

i. Prevents pollution and ecological degradation;

ii. Promotes conservation; and

iii. Secures ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

In support of the above rights, the environmental management objectives of proposed project are to protect ecologically sensitive areas and support sustainable development and the use of natural resources, whilst promoting justifiable socio-economic development in the project areas.

2.1.2 National Environmental Management Act, 1998 (Act No. 107 of 1998)

The National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) provides for cooperative environmental governance by establishing principles for decision making on matters affecting the environment, institutions that will promote cooperative governance and procedures for coordinating environmental functions exercised by organs of state.

NEMA also provides for matters related to sustainable development, which means the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations. To achieve the above objectives, the Act makes provision for the use of the EIA process as a tool for environmentally sound decision-making. The EIA process is regulated in terms of the Regulations published in GN 543 to 546 on 18 June 2010 (“EIA Regulations”), in accordance with the provisions of Sections 24(2) and of 24D of NEMA.

As the project activities associated with the Witwatersrand AMD project require the upgrading of existing infrastructure and the construction and operation of new infrastructure, a Scoping and EIA study is required to comply with NEMA for the authorisation of listed activities contained in GNR 544 of 18 June 2010 (GNR 544) and GNR 545 of 18 June 2010 (GNR 545) published in terms of Sections 24(2) and 24D of NEMA.

2.1.3 National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEMWA).

A waste licence is also required in terms of GNR 718 of 3 July 2009 (GNR 718) published in terms of section 19(1) of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEMWA).

The objectives of the NEMWA is to reform the law regulating waste management in order to protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development. The Act also aims to provide for institutional arrangements and planning matters, to provide for the licensing and control of waste management activities and to provide for compliance and enforcement.

With reference to the Witwatersrand AMD Project, the characterisation and classification of the waste sludge streams needs to be done in accordance to the Department of Water Affairs' *"Minimum Requirements for Handling, Classification and Disposal of Hazardous Waste"* (DWAF, 1998) and a DEA memorandum dated June 2009.

The guide is generally used to determine the hazard rating of waste materials relating to the National Water Act 1998 (Act 36 of 1998) and the partly repealed Environmental Conservation Act 1989 (Act 73 of 1989). The DEA is in the process of revising the waste classification system for South Africa. The final Draft Waste Classification and Management Regulations (WCMR) have been published for comment in September 2010. After finalization, these regulations will be promulgated in terms of the National Environmental Management Waste Act, 2008 (Act 59 of 2008) (NEMWA). These will be integrated during the EIA/EMP phase of this project.

2.1.4 The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)

The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (NEMBA) controls Indigenous Biological Resources. NEMBA provides for the consolidation of biodiversity legislation through establishing national norms and standards for the management of biodiversity across all sectors and by different management authorities.

2.1.5 National Water Act, 1998 (Act No. 36 of 1998)

According to the National Water Act, 1998 (Act No. 36 of 1998) (NWA), a water resource is not only considered to be the water that can be extracted from a system and utilised but the entire water cycle. This includes evaporation, precipitation and entire aquatic ecosystem including the physical or structural aquatic habitats, the water, the aquatic biota and the physical, chemical and ecological processes that link water, habitats and biota. The entire ecosystem is acknowledged as a life support system by the NWA.

A resource is defined to include a water course (which includes rivers and springs, the channels in which the water flows regularly or intermittently, wetlands, lakes and dams into or from which water flows, and where relevant, the banks and bed or the system), surface water, estuary and aquifer.

In terms of the AMD project DWA have directed TCTA in terms of section 103 (2) of the NWA to undertake the emergency works. The directives issued to TCTA are attached in Appendix B.

2.1.6 Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)

The Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983) (CARA) provides for control and conservation of the utilisation of the natural agricultural resources of South Africa in order to promote the conservation of the soil, water sources and vegetation and the combating of weeds and invader plants; and for matters connected therewith. Land owners are obliged, by law, to eradicate alien vegetation on their properties.

For the purpose of the proposed AMD project, the relevant soil and agricultural assessments will be undertaken in order to minimise potential impacts on the agricultural potential or productivity of the sites affected by the project.

2.1.7 National Heritage Resources Act, 1999 (Act No. 25 of 1999)

The National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA) devolves responsibility for the identification of local heritage resources and the inclusion of heritage areas to all municipalities in South Africa. Developers need to incorporate the NHRA and gain approval from the relevant heritage authorities or municipalities before construction may commence.

2.1.8 National Environmental Management: Air Quality Act

The National Environmental Management: Air Quality Act, (Act No. 39 of 2004). (NEMAQA) forms part of the law regulating air quality. The law aims to provide guidance to protect the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development, while promoting justifiable economic and social development. The act also aims to provide for national norms and standards regulating air quality monitoring, management and control by all spheres of government; for specific air quality measures; and for matters incidental thereto.

2.1.9 The National Nuclear Regulator Act, No. 47 of 1999

The National Nuclear Regulator Act, 1999 (Act No. 47 of 1999) aims to provide for the establishment of a National Nuclear Regulator in order to regulate nuclear activities. The act also aims to provide for safety standards and regulatory practices for the protection of persons, property and the environment against nuclear damage and to provide for matters connected therewith. The Department of Minerals and Energy is responsible to service the

Minister's obligations arising from this act, which relates to the governance of the nuclear industry in South Africa and internationally in the specific areas of nuclear technology, nuclear safety and nuclear non-proliferation.

With reference to the Witwatersrand AMD Project, the water currently decanting in the Western Basin is contaminated with heavy metals. If no action is taken in the near future the same fate awaits decanted water in the Central and Eastern Basins. Amongst the heavy metals contained in the AMD contaminated water is Naturally Occurring Radioactive Materials (NORM), of which uranium and its daughter products (radium, polonium and lead) are the main radiological contaminants. Radiological risks are deduced from the radiation doses the receiving environment receives. As part of the EIA process, a Radiological Assessment will be undertaken to determine the associated risks and potential mitigations.

2.1.10 Minerals and Petroleum Resources Development Act (No 28 of 2002)

The Minerals and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA) primarily aims to make provision for equitable access to and sustainable development of the nation's mineral and petroleum resources.

In addition, the MPRDA acknowledges that some mining areas have an interconnected or integrated health, safety, social or environmental impacts that need an integrated approach. Consequently, the relevant mitigation, monitoring and management measures in and around the mining areas need to be considered through a holistic approach for the Witwatersrand AMD project. The environmental management plan for the existing mining areas must be substantial and in compliance with all relevant provisions of Chapter 4 of the MPRDA (Mineral and Environmental Regulation) and Part 3: Environmental Regulations for Mineral Development, Petroleum Exploration and Production, of the Regulations published in GN R527. In particular, Regulation 52 dealing with the compilation of an Environmental management plan will be relevant.

2.2 Policies, guidelines and conventions

In addition to the regulations and guidelines discussed in this chapter, the guidelines and policies of the following organisations will be taken into consideration during the EIA Phase:

- Guidelines implemented by the South African National Biodiversity Institute (SANBI), responsible for exploring, revealing, celebrating and championing biodiversity;
- Guidelines of the World Wildlife Foundation (WWF) South Africa, which aims to conserve the biodiversity assets (endangered wildlife, species, habitats and ecosystems) of South Africa and ensure natural ecosystems and their services are appropriately valued and integrated into sustainable development;
- The International Union for Conservation of Nature and Natural Resources (IUCN) Red List, which is based on information from a network of conservation organisations to rate which species are most endangered;

- Convention Concerning the Protection of the World Cultural and Natural Heritage initiated by the United Nations Educational, Scientific and Cultural Organisation (UNESCO). The Convention aims to protect and conserve the world's natural and cultural heritage. As custodian of unique cultural and natural heritage, South Africa has the responsibility to ensure the identification, protection, conservation, presentation and transmission of cultural and natural heritage sites for future generations;
- The Convention on Biological Diversity that is dedicated to promoting sustainable development. Conceived as a practical tool for translating the principles of Agenda 21 into reality, the Convention recognises that biological diversity is no only centred around plants, animals and ecosystems, but includes people and their need for food security, medical care, fresh air and water, shelter and a clean and healthy environment in which to live; and
- The Convention on International Trade in Endangered Species (CITES) which governs international trade in wild animals and plants.
- The Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

2.3 Directives issued to TCTA

The Minister of Water and Environmental Affairs stated in the directive (Appendix B) to TCTA that the unmanaged AMD situation poses a severe environmental and safety threat to the environment and adjacent surface area as it may cause the following:

- The contamination of surface streams leading to catastrophic ecological disaster;
- Flood urban areas and destroy infrastructure;
- Pose a safety risk by undermining businesses and property around the mines;
- Pollute adjacent groundwater resources; and
- Pose threats to neighbouring mines due to water migration.

TCTA were tasked to implement the project which was:

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

The directive requires TCTA to liaise with the DWA regarding the longer term AMD management objectives and to ensure compatibility of the project with future AMD management measures.

To enable TCTA to implement the immediate and short term steps DWA Gauteng Regional Office further directed TCTA regarding the disposal of sludge arising from the immediate solutions as follows:

- S21G To dispose of the sludge into the West Wits Pits (WWP) together with slime from Mogale City up to surrounding ground level. There are a number of conditions attached to this directive to ensure that potential impacts are understood and that monitoring takes place; and
- S21F TCTA also received a directive from the DWA to discharge the treated water to the Tweelopiespruit at a point above the Krugersdorp Game Reserve. There were a number of conditions on quality which this discharge has to meet as well as requirements for monitoring of both surface and groundwater.

2.4 Application process

Due to activities under both NEMA and NEMWA being applicable to the project an integrated application has been made to the Department of Environmental Affairs (DEA) as provided for in section 24L of the NEMA and section 44 of the NEM:WA.

Authorisation and communication with regards to the project will be by the DEA as required when an integrated application is submitted.

The listed activities which were applied for include listed activities 9, 11, 13, 18, 23, 28, 37 and 39 of GNR 544 and listed activities 3, 5 and 10 of GNR 545. Category A waste management activity 19 and Category B waste management activities 1, 6, 7 and 9 as contained in GNR 718 have been identified as waste management activities that require waste management licences.

It is in terms of these listed activities that TCTA is conducting the studies and processes as detailed in this scoping report.

The relevant departmental reference number for the application is listed in Table 2-1.

Table 2-1: DEA and NEAS reference number

DEA REF. NO.	NEAS REF. NO.
12/1220/2403	DEA/EIA/0000498/2011

The listed activities which will be triggered by the proposed project in terms of the EIA Regulations are detailed in Table 2-2 below.

Table 2-2: Listed activities applicable to the proposed project

GN. R	ACTIVITY	DESCRIPTION
Listing Notice 1: GNR 544 – Activities requiring a Basic Assessment		
544	9.	The construction of facilities or infrastructure exceeding 1000 metres in length for the bulk transportation of water, sewage or storm water – i. With an internal diameter of 0.36 metres or more; or ii. With a peak throughput of 120 litres per second or more, Excluding where: a) Such facilities or infrastructure are for bulk transportation of water, sewage or storm water or storm water drainage inside a road reserve; or b) Where such construction will occur within urban areas but further than 32 metres from a watercourse, measured from the edge of the watercourse.
544	11.	The construction of: i. Canals; ii. Channels; iii. Bridges; iv. Dams v. Weirs vi. Bulk storm water outlet structures; vii. Marinas; viii. Jetties exceeding 50 square metres in size; ix. Slipways exceeding 50 square metres in size; x. buildings exceeding 50 square meters in size; or xi. Infrastructure or structures covering 50 square metres or more where such construction occurs within a watercourse or within 32 metres of a watercourse, measured from the edge of a watercourse, excluding where such construction will occur behind the development setback line
544	13.	The construction of facilities or infrastructure for the storage, or for the storage and handling, of a dangerous good, where such storage occurs in containers with a combined capacity of 80 but not exceeding 500 cubic metres.
544	18.	The infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock from: i. A watercourse; ii. The sea; iii. The seashore; iv. The littoral active zone, an estuary or a distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever distance is the greater – but excluding where such infilling, depositing, dredging, excavation, removal

GN. R	ACTIVITY	DESCRIPTION
		or moving i. Is for maintenance purposes undertaken in accordance with a management plan agreed to by the relevant authority; or ii. Occurs behind the development setback line
544	23.	The transformation of undeveloped, vacant or derelict land to – i. Residential, retail, commercial, recreational, industrial or institutional use, inside an urban area, and where the total area to be transformed is 5 hectares or more, but less than 20 hectares, or ii. Residential, retail, commercial, recreational, industrial or institutional use, outside an urban area and where the total area to be transformed is bigger than 1 hectare but less than 20 hectares.
544	28.	The expansion of existing facilities for any process or activity where such expansion will result in the need for a new, or amendment of, and existing permit or license in terms of national or provincial legislation governing the release of emissions or pollutions, excluding where the facility, process or activity is included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case the Act will apply.
544	37.	The expansion of facilities or infrastructure for the bulk transportation of water, sewage or storm water where: a) The facility or infrastructure is expanded by more than 1 000 metres in length; or b) Where the throughput capacity of the facility or infrastructure will be increased by 10% or more – Excluding where such expansion: i. Relates to transportation of water, sewage or storm water within a road reserve; or ii. Where such expansion will occur within urban areas but further than 32 metres from a watercourse, measured from the edge of the watercourse.
544	39.	The expansion of i. Canals; ii. Channels; iii. Bridges; iv. Weirs; v. Bulk storm water outlet structures; vi. Marinas; Within a watercourse or within 32 metres of a watercourse, measured from the edge of a watercourse, where such expansion will result in an increased development footprint but excluding where such expansion will occur behind the development setback line.
Listing Notice 2: GNR 545 – Activities requiring Scoping and EIA		

GN. R	ACTIVITY	DESCRIPTION
545	3.	The construction of facilities or infrastructure for the storage, or storage and handling of a dangerous good, where such storage occurs in containers with a combined capacity of more than 500 cubic metres.
545	5.	The construction of facilities or infrastructure for any process or activity which requires a permit or license in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent and which is not identified in Notice No. 544 of 2010 or included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case that Act will apply.
545	10.	The construction of facilities of infrastructure for the transfer of 50 000 cubic metres or more water per day, from and to or between any combination of the following: i. water catchments, ii. water treatment works, or iii. impoundments. Excluding treatment works where water is to be treated for drinking purposes.
List of Activities Identified in Terms of GN R 718 of the National Environmental Management: Waste Act, Act 59 of 2008		
CATEGORY A A person who wishes to commence, undertake or conduct an activity listed under this Category, must conduct a basic assessment process, as stipulated in the environmental impact assessment regulations made under section 24(5) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) as part of a waste management Licence application.		
Construction, expansion or decommissioning of facilities and associated structures and infrastructure		
718	19	The expansion of facilities of or changes to existing facilities for any process or activity, which requires an amendment of an existing permit or license or a new permit or license in terms of legislation governing the release of pollution, effluent or waste.
CATEGORY B A person who wishes to commence, undertake or conduct an activity listed under this Category, must conduct an environmental impact assessment process, as stipulated in the environmental impact assessment regulations made under section 24(5) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) as part of a waste management licence application.		
Storage of hazardous waste		

GN. R	ACTIVITY	DESCRIPTION
718	1	The storage including the temporary storage of hazardous waste in lagoons.
Treatment of waste		
718	6	The treatment of hazardous waste in lagoons.
718	7	The treatment of effluent, wastewater or sewage with an annual throughput capacity of 15 000 cubic metres or more.
Disposal of waste on land		
718	9	The disposal of any quantity of hazardous waste to land,

2.4.1 Environmental application

Due to the rising water levels in the Central Basin and the fact that decant is already occurring in Western Basin, it is likely that the construction of the water treatment plants in these basins will commence prior to the finalisation of this EIA. Various options for the approval of these activities were considered.

It was initially proposed that a section 28 directive be issued by the DEA, in terms of which both the immediate and short term solutions may lawfully continue as a parallel process in obtaining the necessary environmental authorisations in respect of NEMA and NEMWA. Section 28(1) provides that "*Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment*." Section 28(4) provides that: "*The Director-General or a provincial head of department may, after consultation with any other organ of state concerned and after having given adequate opportunity to affected persons to inform him or her of their relevant interests, direct any person who fails to take the measures required under subsection (1) to—*

> *(a) investigate, evaluate and assess the impact of specific activities and report thereon;*
>
> *(b) commence taking specific reasonable measures before a given date;*
>
> *(c) diligently continue with those measures; and*
>
> *(d) complete them before a specified reasonable date:*

Provided that the Director-General or a provincial head of department may, if urgent action is necessary for the protection of the environment, issue such directive, and consult and give such opportunity to inform as soon thereafter as is reasonable."

The directive, however, can only be issued to the offender or the entity that caused the pollution or degradation to the environment, which TCTA are not. By commencing with any listed activity, as set out in Table 2-2, before authorisation has been received, TCTA would be initiating illegal activities which would require a rectification of these unlawful actions. This would, therefore, require the submission of a section 24G application in terms of NEMA. This, however, would place TCTA in an untenable position due to the fact that criminal liability could accrue for activities which they have been directed to rectify.

It is possible that other interpretations of the provisions of NEMA may avoid the implication of unlawful activities, or that exemption from the provisions of NEMA may be granted. The EIA process for the Eastern Basin, however, should be completed before construction commences as the water level is considerably lower than that of the Central Basin, and hence the need for exemption is less urgent in this case.

3 ENVIRONMENTAL ASSESSMENT PRACTITIONER

3.1 Digby Wells Environmental

Digby Wells was appointed by TCTA as the independent Environmental Assessment Practitioner (EAP) responsible for undertaking the EIA process for the proposed immediate and short term interventions for the treatment of AMD in the Western, Central and Eastern Basins. Digby Wells is a South African company with international expertise in delivering comprehensive environmental and social solutions for clients in diverse sectors including the energy, minerals, and mining industries. A company profile has been attached to this report as Appendix C.

3.2 Project team

A team of environmental and social specialists were commissioned to conduct the relevant tasks associated with the Scoping Phase of the project. The specialists and their roles are listed in Table 3-1 below. Copies of their CVs have been attached to this report as Appendix D.

Table 3-1: Digby Wells project team

ASPECT	SPECIALIST	QUALIFICATIONS AND COMPETENCY
Project sponsor	Graham Trusler	1983-1986 BSc Chemical Engineering (UN) 1987-1988 MSc Engineering (UN) 1991 B Comm (Unisa) Professional Engineer
Project manager and Environmental Assessment Practitioner (EAP)	Grant Beringer	2004 – 2006: MSc Environmental Management –UJ 2002 – 2003: BSc (Honours) Geography and Environmental Management (*Cum Laude*) – RAU 2000 – 2002: BSc Earth Sciences – RAU
Public Participation	Steve Horak	2005: BA Masters Environment and Society – University of Pretoria 1999: BA Honours Development Administration – University of South Africa 1994: BA Applied Anthropology-Development studies – University of Pretoria

4 PROJECT DESCRIPTION

4.1 Project background

In the Western Basin, the AMD started to decant from an old shaft in September 2002. AMD in the Central and Eastern Basins will decant in the next few months or years, and thus, urgent action is required to mitigate or prevent AMD decanting uncontrolled or untreated into the environment. In 2010, Cabinet appointed an IMC to address the serious challenges posed by AMD in the Witwatersrand Gold Fields area. The IMC tasked a Technical Committee, to investigate the AMD issues. The Technical Committee subsequently appointed a team of experts, who developed and presented a draft report on AMD to Cabinet on 9 February 2011. The report recommended three interventions for the management of AMD.

- Firstly, an immediate intervention, to neutralise acid water already decanting from the Western Basin;
- Secondly, a short term intervention, by pumping water from the Western, Central and Eastern Basins to prevent surface decant and to neutralise this water before release into the environment; and
- DWA is currently considering the implementation of the third intervention, a long term intervention, which includes the removal of salts from AMD water.

In addition to the above mentioned interventions the IMC recommended that water ingression into the mine workings, be investigated and reduced wherever possible.

The first two interventions, namely the immediate and short term interventions, are to be the first phases of the long term intervention for AMD. The objective of this first phase is to maintain the underground water levels below the ECL, in the Central and Eastern Basin and to stop the decant in the Western Basin by reducing the water levels below the ECL.

The ECL is governed by the geology and the mining voids in the basins. Due to the presence of dolomite formation in the Western and Eastern Basins, the ECLs in these basins have been selected in order to protect the formations which contain significant aquifers. In the Central Basin there are no sensitive aquifers, however, by maintaining the water level below the chosen ECL, groundwater users would be protected against contamination of their water. The ECLs for the three basins are shown in Table 4-1.

Table 4-1: ECLs for the three basins

Basin	ECL (mamsl)
Western	1 550
Central	1 467
Eastern	1 280

The water levels in the Central and Eastern Basins are currently below the ECL, however, water is decanting on surface in the Western Basin. The water level will, therefore, need to be drawn done below the ECL in the Western Basin.

The primary aim of the short term intervention for the treatment of AMD from the Western, Central and Eastern Basins of the Witwatersrand is, therefore, to treat the mine water to a level that it can be discharged to the environment, with tolerable impacts on downstream water users. This requires neutralisation of the acidic mine water and precipitation and removal of heavy metals.

4.2 Need and desirability for the project

Although the problem of AMD has been known for many years, little has been done to provide for a solution to its management. As stated AMD started to decant in the Western Basin in 2002 and has largely been flowing into the environment untreated. This provides an indication of what the impacts could be if nothing is done about its management and treatment. If left to its own devices, this decant will continue indefinitely, causing a host of environmental and socio-economic impacts, some of which have already been realised. The Central and Eastern Basins have yet to decant, but, it is predicted that AMD will flow to surface there in December 2014 and August 2016 respectively. It is this scenario which led the IMC to suggest that intervention is urgently required should we wish to mitigate and manage negative impacts on the surrounding environments of the Witwatersrand Gold Fields.

The immediate intervention on the Western Basin is required to increase the pH of the water currently flowing into the Tweelopiespruit, and to reduce the salt load and dissolved heavy metals. Rand Uranium is currently treating approximately a third of the flow from the old workings while the remainder is allowed to flow untreated into the environment. The ecological effects of this untreated effluent have been very well publicised.

4.2.1 Process and timing

Due to the rising water levels in the Central and Eastern Basins it is critical that interventions to prevent the decant of AMD, as is occurring in the Western Basin, are implemented. The relevant time constraints and processes to address the issue are described below.

4.2.1.1 Western basin

The immediate intervention will involve the upgrade and retrofitting of the existing Rand Uranium treatment plant. The upgrade will allow the plant to neutralise the current decant volumes, thereby, extracting the majority of the heavy metals, before the water is released into the environment. The upgrade of the Rand Uranium treatment plant will be funded by TCTA, however, the responsibility of its operation is that of Rand Uranium. The upgrade of the plant will, therefore, be handled with an amendment to the original Environmental Management Programme Report for Rand Uranium. In addition to the immediate intervention, it has been proposed that a short term intervention be put in place order to ensure the desired ECL is achieved.

Water is decanting at an annual average of approximately 30 Ml/day. For the short term solution it is proposed to lower the level of water in the workings and to bring it to a level where it will not affect surrounding aquifers. In order to achieve this more water will need to be pumped out until the ECL is reached. It is also proposed that this water will be treated through an HDS Plant, prior to its release into the environment. The simultaneous operation of the immediate and short term plants will provide for the treatment of sufficient volumes of AMD to ensure that the ECL, which is approximately 165 m below surface at Shaft No. 8, can be reached within 2- 3 years after commissioning of both the Immediate and Short Term solutions. Thereafter, the Rand Uranium plant will be decommissioned and only the short term plant will operate in isolation to maintain the water level below or at the ECL.

4.2.1.2 Central Basin

Water within this basin is rising and in order to prevent this water from decanting at surface similar to what is occurring in the Western Basin there are plans in place to pump the water in order to ensure that the ECL is not exceeded. It is also proposed to treat this water in a HDS plant. The ECL for the Central Basin was found to be 150 m below the East Rand Proprietary Mines (ERPM) Cinderella East Shaft collar level (1 617 m) or 1 467 mamsl (186.2m below SWV). It has been estimated that the ECL will be reached in August 2013 and that if intervention did not occur decant would occur in December 2014.

4.2.1.3 Eastern Basin

Water within this basin is rising and in order to prevent this water from decanting at surface similar to what is occurring in the Western Basin there are plans in place to pump the water in order to ensure that the ECL is not exceeded. It is also proposed to treat this water in a HDS plant. The ECL for the Eastern Basin was found to be 1 280 mamsl. It has been estimated that the ECL will be reached in May 2014 and that if intervention did not occur decant would occur in August 2016.

Due to the imminent decant in the Central and Eastern Basins and the current decant in the Western Basin it is clear that intervention is required. The IMC Report proposed that the following recommendations be implemented to prevent AMD decanting:

- Installation of pumps to extract AMD from the mines to on-site treatment plants;
- Construction of on-site water treatment plants in each basin, with the option of refurbishing and upgrading existing treatment facilities owned by the mines; and
- Installation of infrastructure to convey treated water for discharge into nearby water courses.

4.2.2 The long term solution

To achieve the recommendations from the IMC report, it was proposed to establish the immediate and short terms interventions as phase 1 of the long term sustainable solution. Any long term solution needs to be sustainable and in order to achieve this, relevant technology for the indefinite treatment of and use of the product water must be employed. The objective of the long term treatment technology is to neutralise as well as desalinate the AMD to achieve potable or other standards. There may be other uses for the treated water.

The technologies to realise this are available, however, investigation into what type of technology is used must be conducted to ensure the long term feasibility of the solution. In addition the long term solution must be financially viable and not be a burden on Government and its resources. To ensure this, institutional arrangements must be put in place where the government and private entities contribute to the sustainable operation of the long term solution. It is, therefore, crucial that the long term solution is thoroughly investigated in terms of the technology used and that the financial implications are well understood before its implementation. To bring the long term solution into operation before decant occurs is, therefore, improbable and it would be negligent of Government to do so without the necessary investigations and consultations.

The development and implementation of short term infrastructure will take the long term management of AMD into account. The proposed HDS technology will form part of the long term solution as the long term treatment of AMD will require neutralisation to occur prior to any form of desalination.

4.2.3 Water quality

With the construction and operation of the proposed short term treatment plants, the water quality will be improved considerably as opposed to letting it decant naturally without treatment. The mine water from all three basins is acidic with a high metal content and high salinity. The Western Basin's water has been measured to have a Total Dissolved Salts (TDS) concentration of above 7 000 mg/l (most of which is sulphate and calcium) and a pH of 3.4. The water in the Central Basin shows TDS concentrations of 7 700 mg/l and a pH of 2.3, whereas the Eastern basin has TDS levels of 5,500mg/l and a higher pH of 5, as shown in Table 4-2.

The proposed short term treatment will aim to neutralise free and metal acidity to neutral pH, as well as allow for the removal of metals from the AMD in the form of metal hydroxides to within DWA standards. The precipitation and removal of the uranium from the water will also occur during the short term treatment of AMD. Although desalination will occur during the short term treatment it will be limited. It is proposed that the treated water will have a pH of 6 – 9 before release. Iron concentrations will be reduced from an average of 651.5 mg/l across the basins to < 1. Uranium levels will be decreased to < 50 µg/l and sulphates to < 2 400 mg/l (currently the average across the basins is 4 343.67 mg/l) reducing the TDS levels of the treated water (Table 4-3). The objectives of the short term treatment are therefore to:

- Neutralise the mine water and produce a near-neutral treated mine water with some residual buffer capacity in the form of alkalinity;
- Remove the main metals, specifically iron, aluminium and manganese to acceptable short-term discharge standards;
- Remove radionuclides, specifically uranium to acceptable short-term discharge standards; and
- Achieve a degree of desalination by removing gypsum (CaSO4) in excess of the saturation levels.

Table 4-2: Expected water quality by basin before treatment

Water quality Parameter	Units	Western Basin (95th percentile)	Central Basin (95th percentile)	Eastern Basin (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	2.3	5.0
Acidity ($CaCO_3$)*	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

Water quality Parameter	Units	Western Basin (95th percentile)	Central Basin (95th percentile)	Eastern Basin (flooded condition)
Uranium (U)	mg/ℓ	0.2	--	--

pH values are for 5th percentile

Table 4-3: Target mine water discharge standards

Water Quality Variable	Units	Concentrations
pH	-	6-9
Iron	mg/ℓ	<1
Manganese	mg/ℓ	<3
Aluminium	mg/ℓ	<1
Uranium	µg/ℓ	<50
Sulphate	mg/ℓ	<2 400

4.2.4 Water quantity

By implementing the short term intervention it is likely that the water levels will remain below the ECLs in the Central and Eastern Basins mitigating potential environmental impacts. The ECL associated with each of the mining basins is defined as "the mine water level below which, the risk of negative impacts on the shallow economically exploitable groundwater resources and the surrounding surface water resources is small." Should the water levels in the Central and Eastern Basins be left to rise above the ECL and decant, there is the real risk that the weathered and fractured aquifers in the Central and the dolomitic formations in the Eastern Basin will be contaminated by AMD. The water level in the Western Basin needs to be lowered to prevent the spread of pollution.

4.2.5 Technology

Treatment technology and chemical reagent combinations recommended for the treatment of the Witwatersrand AMD is as follows:

- Oxidation by aeration;
- Pre-neutralisation with limestone;
- Neutralisation and metals removal with lime, produced by the slaking of quicklime; and
- Gypsum crystallisation to remove excess sulphate from solution.

The HDS Plants to be constructed for the short term intervention are based on technology that is proven to be effective (and cost effective) in the treatment of AMD at full-scale applications. Other neutralising chemicals can be used but these are generally a lot more expensive than limestone and lime.

The HDS process is seen as an active process and more suited to the treatment of AMD than passive treatment. Passive treatment systems have been tried and tested but they are mainly implemented for treating low flow systems and diffused flow systems, as stated in the International Network for Acid Prevention's (INAP) Global Acid Rock Drainage Guide. They are generally unsuitable for large flows.

The HDS plants will also be required as part of the long term treatment of AMD as neutralisation of the AMD will be required prior to desalinisation. The treatment plants for neutralisation must, therefore, have a high level of reliability in order to serve the proposed mine water reclamation plants for a long time. The HDS technology has been identified to provide this reliability in the long term.

4.2.6 Location

The locations of the short term plants were evaluated by BKS during their Due Diligence study. The locations of the plants were assessed based on the needs of the long term solution too. The site selection considered the following:

- Availability of land on an uncompromised site with favourable geotechnical conditions, off the dolomitic formations;
- Central location from the perspective of future reclaimed water distribution to Rand Water and municipal reservoirs;
- Good access and supply of bulk services, such as electrical power;
- Feasible and practical options for long-term waste sludge disposal;
- Flexibility in terms of neutralised water discharge;
- An estimate of the space requirement for the future long term scheme was made and any land procured for the short term intervention must provide sufficient land for implementation of a long term scheme;
- Sludge handling will be a long term requirement and the short term solution has thus reviewed how sludge can be handled in the long term (30+ years). The long-term requirements need to be analysed and discussed with the various mines; and
- Consideration of where the potential connection to the potable water system would be, i.e. by reviewing potential water demand and water distribution reservoirs. Detailed water distribution and master planning needs to be part of the long term solution.

4.2.7 The no-go option

Should the immediate and short term intervention for the treatment of AMD from Witwatersrand Goldfield Basins not proceed, untreated AMD will continue to decant in the Western Basin and untreated and uncontrolled AMD decant will start in the Central and Eastern Basins. The uncontrolled decant of AMD into the environment may have devastating ecological and social impacts in the respective areas, which will eventually spread to the Vaal River and Crocodile River systems. The Witwatersrand AMD Project, therefore, needs to be implemented to mitigate and prevent additional impacts of AMD. The IMC Team of Experts report indicated that underground water levels needed to be kept below an ECL and that the water needs to be treated before being released back into the environment. Maintaining water at the ECL levels will prevent future AMD decanting and prevent the flooding of lower level aquifers.

4.3 Project location

For the immediate intervention, the Rand Uranium water treatment plant will be upgraded in the West Rand. For the short term intervention, new water treatment plants will be constructed in three areas (Plan 2):

- The Randfontein Estates area - Western Basin;
- The ERPM South West Vertical Shaft area - Central Basin; and
- The Grootvlei Mine Shaft No.3 area - Eastern Basin.

It has been proposed that the disposal of the sludge takes place at the following existing TSFs:

- West Wits Pit – Western Basin;
- The Brakpan TSF – Central Basin; and
- Brakpan, Grootvlei and/or Daggafontein TSFs – Eastern Basin.

The abstraction of AMD water will take place at the following shafts:

- Rand Uranium Shaft No. 8 – Western Basin;
- ERPM South West Vertical Shaft – Central Basin; and
- Grootvlei No. 3 Shaft – Eastern Basin.

4.3.1 Land tenure

The portion numbers and owners of the land on which the infrastructure for the short term intervention for the AMD project are to be constructed is summarised in Table 4-4.

Table 4-4: Land Tenure for the treatment infrastructure

Basin	Farm Name	Portion Number	Name of Landowner
AMD Abstraction			
Western	Uitvalfontein 244 IQ	Remainder	Randfontein Estates Limited
Central	Driefontein 87 IR	Remainder of Ptn 1	Witwatersrand Gold Mining Realisation Trust
Eastern	To Be Confirmed	TBC	TBC
Treatment Plants			
Western	Randfontein 247 IQ	Ptn 1 R/E	Western Areas Limited
Central	Driefontein 87 IR	Remainder of Ptn 1	Witwatersrand Gold Mining Realisation Trust
Eastern	TBC	TBC	TBC
Discharge Points			
Western	Waterval 174 IQ	Remaining Extent	No data available
Central	Driefontein 682 IR	Remainder	Shanike Inv No 55 Pty Ltd
Eastern	TBC	TBC	TBC

Note: TCTA have yet to procure the land from DRD Gold for the construction of the treatment plant and abstraction infrastructure on the ERPM South West Vertical Shaft area. Agreements have also yet to be reached between Mogale Gold, DRD Gold and Grootvlei Gold Mine (or liquidators thereof) for the use of the West Wits Pits, Brakpan and/or Daggafontein TSF and the Grootvlei TSF for the storage of sludge respectively. In addition, agreements with Rand Uranium and Grootvlei Mine (or liquidators thereof) for the treatment plant and abstraction infrastructure have not been concluded.

The Witwatersrand Gold Fields are divided into four basins; the Far Western Basin, Western Basin, Central Basin and Eastern Basin. The immediate and short term interventions, however, focus on the Western, Central and Eastern Basins (Plan 1). Details of the locations of each basin are detailed below and illustrated in Table 4-5.

4.3.2 Western Basin

The Western Basin is located in the Krugersdorp, Witpoortjie and Randfontein areas. The mine lease areas in the basin cover about 57 km². Mintails is active in the basin area with re-mining of old tailings dams and dumps. Rand Uranium is also re-mining selected sand dumps and is planning to reclaim slimes dams and commence possible underground mining. Past mining in the basin has created an underground mine void volume of approximately 43 Mm^3 at ECL. The cessation of mining in the basin has resulted in progressive flooding of the void since 1997, until water started to decant from an old shaft in September 2002. The decant points are all located in the north-western section of the Old Randfontein Estates Mine. A portion of the decanting mine water is intercepted at the decant point referred to as the Black Reef Incline Shaft (BRI) and pumped to a mine water treatment facility, namely the Rand Uranium treatment plant, before being released to the Tweelopiespruit. The combined treated and untreated AMD flows down the Tweelopiespruit towards the Crocodile River West. Approximately one third of the decant is currently being treated at the Rand Uranium treatment plant.

4.3.3 Central Basin

The Central Basin extends from Durban Roodepoort Deep (DRD) in the west to ERPM in the east. The mine lease areas in the basin extend cover about 251 km^2. The study area consists of 12 underground mines, with only Central Rand Gold (CRG) mining the Consolidated Main Reefs property still operational. There are numerous surface operations reclaiming sand dumps and slimes dams. Mining has created an underground mine void volume of approximately 280Mm^3 at ECL. The underground mines are interconnected, but due to the elevations of the holings between the mines, the Central Basin can be divided into four sub-compartments, DRD sub-compartment, Rand Leases sub-compartment, Central sub-compartment and ERPM sub-compartment. If allowed to fill, however, it can be expected that all the water will run to the east and will decant from one or more shafts on the ERPM property. It has been estimated that the ECL will be reached in August 2013 and that if intervention did not occur decant would occur in December 2014.

4.3.4 Eastern Basin

The Eastern Basin covers the East Rand area, including the towns of Boksburg, Brakpan, Springs and Nigel. The mine lease areas in the basin cover about 768 km^2. In 2010, the last operational deep-level gold mine in the Eastern basin, Grootvlei Gold Mine, ceased operation due to bankruptcy. Therefore, only Gold One, who is operating a mine close to Nigel, is still operating in the Eastern Basin. They have also recently, purchased the Grootvlei Gold Mine and may plan future mining there. Mining has created an underground mine void volume of approximately 400Mm^3 at ECL. The mining basin comprises three sub-basins: Sallies, Eastern and Brakpan. However, at the current water level and in future at the ECL, the sub-compartments operate as a single basin. If pumping does not take place the ECL will be reached in will be reached in May 2014 and decant would occur in August 2016.

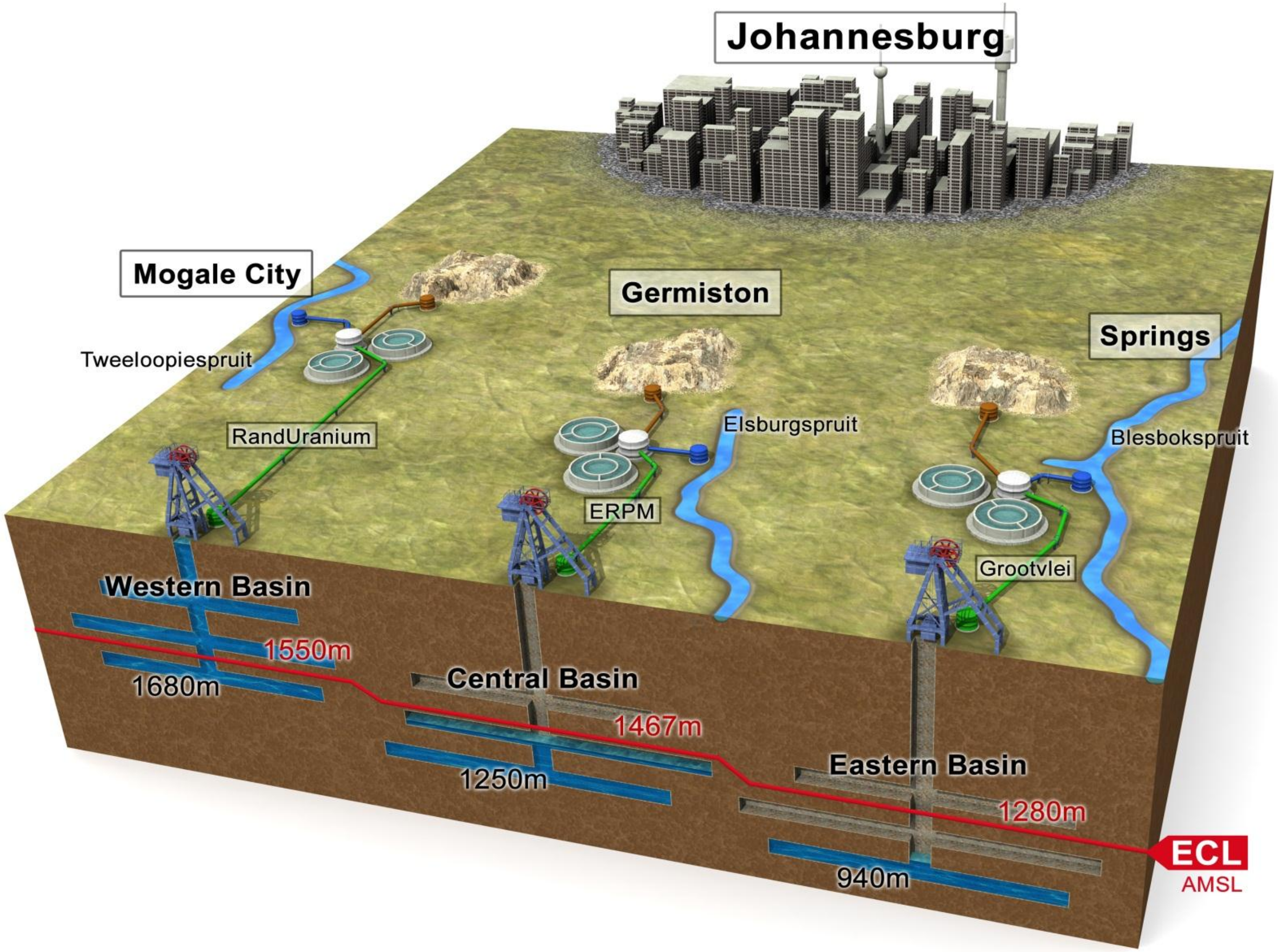

Table 4-5: The locations of the proposed treatment plants and the water levels of the three basins.

4.4 Treatment technology

Through the due diligence process, the following treatment technology and chemical reagent combinations are recommended for the treatment of the Witwatersrand AMD:

- Oxidation by aeration;
- Pre-neutralisation with limestone;
- Neutralisation and metals removal with lime, produced by the slaking of quicklime; and
- Gypsum crystallisation to remove excess sulphate from solution.

The HDS treatment technology has been selected to treat the AMD during the immediate and short term interventions.

The HDS process generally involves the following:

- Addition of an alkali, typically lime in the slaked lime or un-slaked lime form;
- Aeration to oxidise the iron and manganese;
- Neutralisation of the free and metal-related acidity;
- Precipitation of the metals in the hydroxide or carbonate form;
- Solids separation and production of clear neutralised water; and
- Handling and disposal of waste sludge, which mainly contains metals hydroxides and gypsum.

The HDS process is recognised as the preferred method of treating mine water containing high metal concentrations. This process has been well known for a number of years and has been applied at a number of mines worldwide and in other industries with similar waste waters such as the steel producing and pickling plants.

It allows for neutralisation of acidic waters, the removal of metals and a large proportion of the dissolved salts. A number of other processes can do the same but the reason the HDS process has been implemented on a large scale is because it can produce a relatively dense sludge, thus, reducing sludge volumes and assisting with the management and disposal of this sludge.

A South African innovation which has been introduced into the proposed project is to save costs (without affecting the treatment process) by conducting the initial neutralisation with limestone and then only using slaked lime for the subsequent stages of neutralisation.

The proposed process, shown in Table 4-7 requires the oxidation of dissolved ferrous iron (Fe^{2+}) and manganese in the AMD through aeration. The oxygen will be introduced by mechanical aeration equipment. If this stage does not occur the Fe^{2+} will not be oxidised prior to the introduction of an alkali, the lime/limestone particles may become coated with precipitation product and, therefore, be less effective.

The next stage of the process is pre-neutralisation with limestone ($CaCO_3$) to increase the pH before the neutralisation stage. During neutralisation, lime produced by the slacking of quicklime will be used. Unslaked quicklime has to be slaked ($Ca(OH)_2$) or hydrated prior to application. This requires slaking equipment that mixes water with quicklime under controlled conditions as the reaction is exothermic. Through the neutralisation of the AMD the pH is adjusted to a level which facilitates the formation of metal precipitates. Table 4-6 shows the pH condition where certain metal hydroxides have minimum solubility.

Table 4-6: Minimum metal hydroxide solubility pH

Metal	pH at minimum solubility
Ferric iron (Fe^{3+})	~3.5
Antimony (Sb^{2+})	~4.2
Aluminium (Al^{3+})	~4.5
Lead (Pb^{2+})	~6.5
Copper (Cu^{2+})	~7.0
Ferrous iron (Fe^{2+})	~8.0
Zinc (Zn^{2+})	~8.5
Nickel (Ni^{2+})	~9.3
Cadmium (Cd^{2+})	~10.0
Manganese (Mn^{2+})	~10.6

By elevating the pH, the process facilitates the precipitation of sulphate as gypsum ($CaSO_4$). The precipitated gypsum sludge is recycled to seed and enhance the further precipitation of gypsum on sludge seed particles and, thus, increase the removal efficiency.

After neutralisation the water will flow into a clarifier where sufficient reaction time will be allowed to provide the slow growing metal hydroxide and gypsum crystals time to form and grow, which creates a dense sludge.

The treated and neutralised water resulting from the process will then be discharged into the receiving streams.

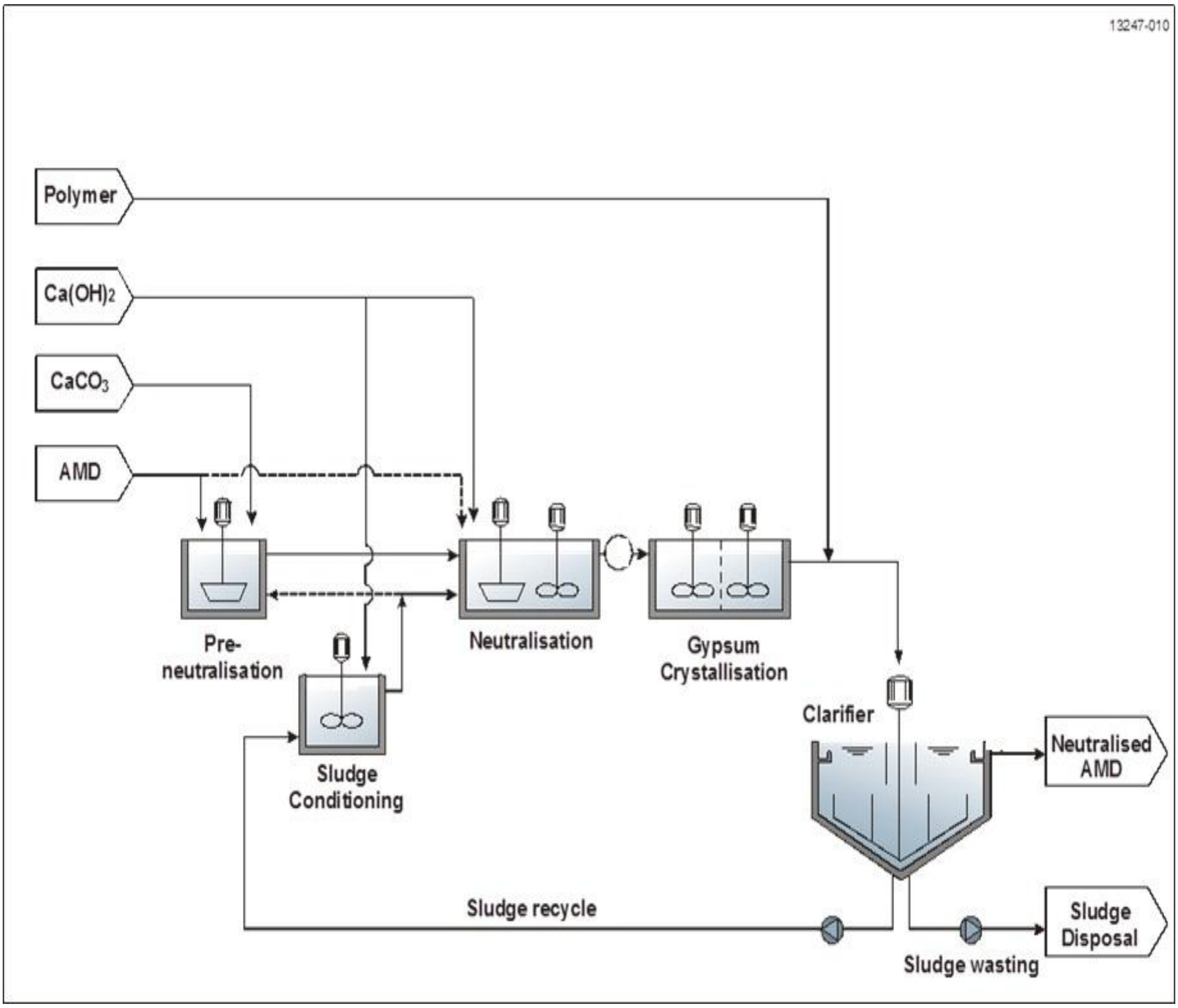

Table 4-7: The proposed HDS process for the treatment of AMD for the immediate and short term interventions

4.5 Preliminary project layout and design

4.5.1 Conceptual site layout

The construction of infrastructure will comprise of:

- Infrastructure around the shafts (for the abstraction of AMD);
- HDS treatment plants at each basin;
- Pipeline construction to various streams (for discharge);
- Pipeline construction to treatment works from the point of abstraction;
- Pipeline construction to sludge disposal areas (sludge disposal); and

- Roads and areas used for transportation and access (servitudes).

Construction activities will be confined to the designated project areas, as defined by the Engineer (BKS). Details of each Basins conceptual layout are given below.

4.5.1.1 Western Basin

4.5.1.1.1 Immediate intervention - Plan 3

The existing Rand Uranium Water Treatment Plant is in close proximity to the abstraction point, Shaft No. 8. Close geographical location to the abstract point is essential due to the potential for oxidation, scaling and corrosion occurring within the pipelines.

- No additional development is foreseen. Existing facilities will be refurbished and upgraded; therefore, the footprint of the existing facility will not be increased;
- Access to the site will be along existing roads;
- Electrical power supply is currently being supplied to the site by existing overhead power lines;
- Potable water and reagent make up water (2 Ml/day) will be supplied from the existing Rand Water supply line; and
- Sewage on site will be disposed of in the existing conservancy tank.

4.5.1.1.2 Short term intervention - Plan 4

The treatment plant will consist of two independent trains, each comprising a sludge conditioning tank, a pre-neutralisation tank, a neutralisation tank, a gypsum crystallisation tank and a clarifier / thickener. Other than these main unit processes, other ancillary treatment infrastructure includes:

- Chemical dosing (quick lime, limestone and polyelectrolyte);
- Pumps and equipment for the sludge recycle system;
- Sludge pipeline to the disposal facility; and
- Buildings for the electrical equipment.

4.5.1.2 Central Basin

The treatment plant will consist of two independent trains, each comprising a sludge conditioning tank, a pre-neutralisation tank, a neutralisation tank, a gypsum crystallisation tank and a clarifier / thickener. Other than these main unit processes, other ancillary treatment infrastructure includes:

- Chemical dosing (quick lime, limestone and polyelectrolyte);
- Pumps and equipment for the sludge recycle system;

- Sludge retention tank (one-day storage to allow for breakdown / maintenance at Knights plant);
- Treated water retention tank (one hour storage as pump sump for potential mine use of the water);
- Sludge pipeline to the disposal facility; and
- Buildings for the electrical equipment.

The general position of the site infrastructure is shown in Plan 5.

4.5.1.3 Eastern Basin

The treatment plant will comprise three independent trains, each consisting of a sludge conditioning tank, a pre-neutralisation tank, a neutralisation tank, a gypsum crystallisation tank and a clarifier / thickener.

Other than these main unit processes, other ancillary treatment infrastructure includes:

- Chemical dosing (quick lime, limestone and polyelectrolyte);
- Pumps and equipment for a sludge recycle system;
- A sludge retention tank (one-day storage to allow for breakdown / maintenance at the receiving plant);
- A treated water retention tank (one-hour storage as pump sump for potential use of the water);
- Waste sludge pipeline to transport the sludge to the storage facility; and
- Buildings for the electrical equipment.

The location of the treatment plant and proposed discharge pipeline is shown in Plan 6.

4.5.2 Electricity supply

4.5.2.1 Western Basin

The proposed plant is adjacent to an Eskom sub-station and power will be obtained directly from Eskom. The electrical power supply voltage will be stepped down to 400V to supply electricity to the various Motor Control Centres (MCCs).

4.5.2.2 Central Basin

There is an Eskom sub-station on site and power will be obtained directly from Eskom. The electrical power supply voltage will be 6.6 kV to the pumps, but will be stepped down to 400 V to supply electricity to the treatment plant's various MCCs.

The following electrical infrastructure will be required at the plant:

- Mini-substation, rated for current use and pumps to future treatment works;

- A Low Voltage (LV) Room, including auxiliary items such as a control desk and remote control via fibre optic back to the control building; and
- Electrical controls and protection.

4.5.2.3 Eastern Basin

There are Eskom power lines close to the proposed site and power will be obtained directly from Eskom. The electrical power supply voltage will be 6.6 kV to the pumps, but will be stepped down to 400 V to supply electricity to the treatment plants various MCCs.

The following electrical infrastructure will be required at the plant:

- A mini-substation, rated for current use and pumps to future treatment works;
- A LV Room, including auxiliary items, control desk and remote control via General Packet Radio Service (GPRS) or fibre optic back to the control building; and
- Electrical controls and protection.

4.5.3 Site access

4.5.3.1 Western Basin

The existing access road to the North-East Shaft and to the electrical sub-station can be upgraded and used to access the treatment plant site.

4.5.3.2 Central Basin

An access road to the south of the SWV site will provide good access for the regular delivery of lime by larger trucks. The road is through an industrial area and the additional traffic load will be negligible.

4.5.3.3 Eastern Basin

A new access road to the east of the site is proposed as it will be a good access point for the regular delivery of lime by larger trucks. The road is through a rural / farming area and the additional traffic load will have to be considered in terms of the disturbance to local residents.

4.5.4 Water supply

4.5.4.1 Western Basin

A water connection will be installed from the municipal bulk distribution system that supplies the area.

4.5.4.2 Central Basin

A water connection will be installed from the municipal bulk distribution system that supplies the industrial area.

4.5.4.3 Eastern Basin

A municipal water supply will be preferred; but if this is not available, a borehole will be drilled into the dolomite to provide potable water to the site. A small package plant for filtration and disinfection will be provided.

4.6 Project activities

The activities to be undertaken during the phases of the proposed project and their estimated timeframes are briefly described below. The construction phase of the proposed short term intervention is not anticipated to take longer than 14 months (Western and Central Basins) and 18 months (Eastern Basin). The construction phase, however, may commence prior to the completion of the EIA and it may, therefore, be required to submit a section 24G application.

4.6.1 Western Basin

4.6.1.1 Immediate intervention

Immediate intervention measures will include the upgrading and retrofitting of the existing Rand Uranium water treatment plant by bringing the plant's additional treatment trains back into operation. The upgrade of the Rand Uranium water treatment plant requires a number of construction activities. The activities for both the construction and operational phases required for the immediate intervention are listed below. .

- Installation pipelines for the abstraction of water from Shaft No. 8;
- Abstraction of water from Shaft No. 8;
- Treatment of the AMD;
- Pumping of treated sludge to the CPS pit;
- Sludge removal from CPS pit and disposal in the West Wits Tailings Deposition site; and
- Discharge of treated water from the CPS pit into the existing outflow trench before joining the Tweelopiespruit.

With reference to the activities discussed above, Table 4-8 presents a schematic illustration of the immediate intervention in the Western Basin.

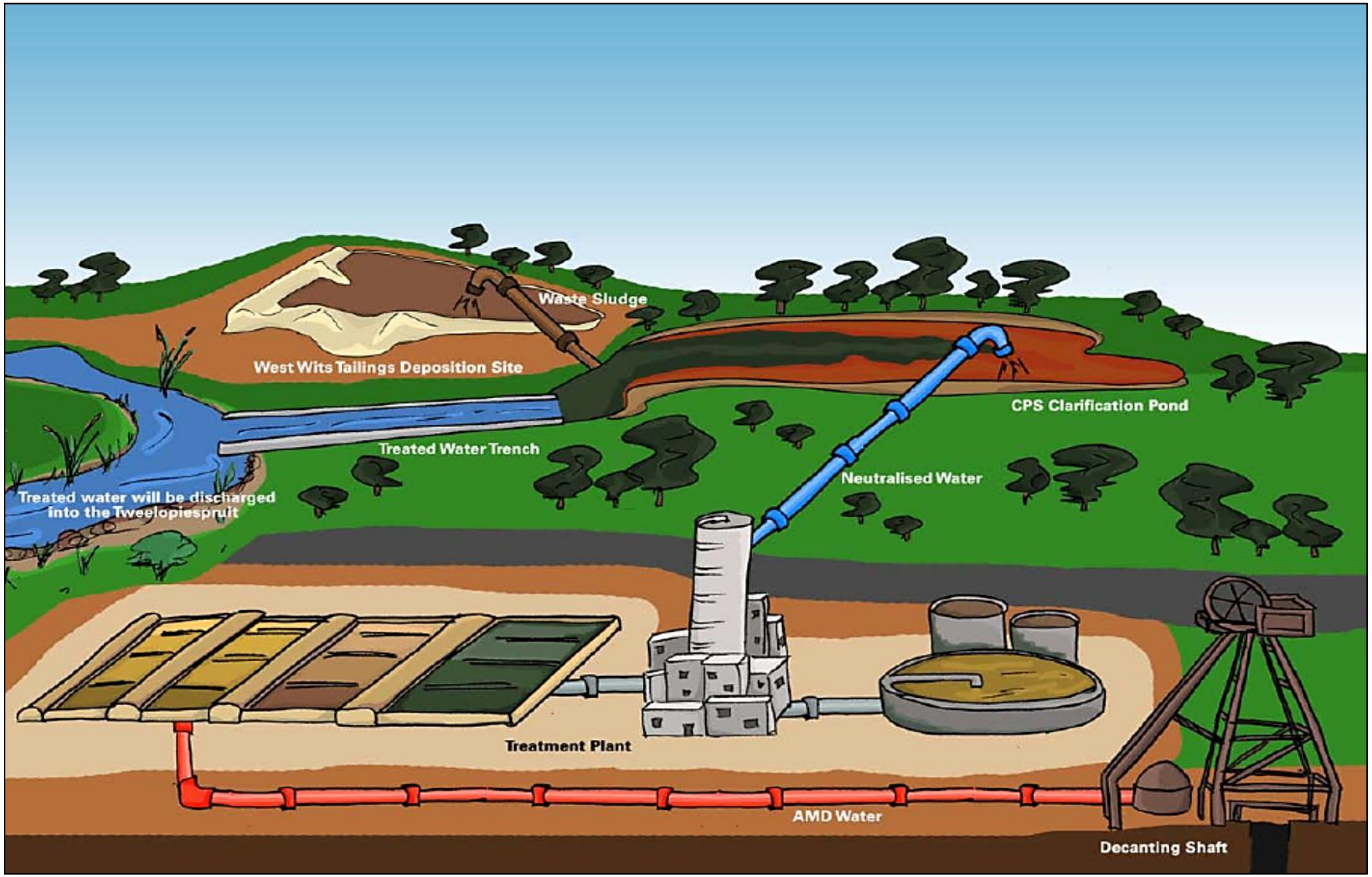

Table 4-8: Immediate intervention – Western Basin

4.6.1.2 Short Term intervention

The short term intervention activities for the Western Basin will include:

- Abstraction of AMD via pumps installed in Shaft No. 8 to achieve the ECL;
- Construction and operation of a new HDS treatment plant on the Randfontein Estates site;
- Construction and operation of a treated water pipeline to a suitable discharge point on the Tweelopiespruit within the Krugersdorp Game Reserve; and
- Construction and operation of waste sludge disposal pumps and pipeline to the West Wits Pit.

4.6.2 Central Basin

The activities for the short term intervention will include:

- Abstraction of AMD via pumps installed in the SWV Shaft to retain the water level beneath the ECL;
- Construction and operation of a new HDS plant adjacent to the SWV Shaft;
- Construction and operation of a waste sludge pipeline to the Crown Knights Gold processing plant;
- Construction and operation of a treated water pipeline to a suitable discharge point on the Elsburgspruit; and
- The potential for the construction and operation of a waste sludge pipeline to the DRD Gold Knights (Crown) Gold Plant, with a view to deposit on the Brakpan TSF. It is not known whether existing pipelines to the facility will be used or whether a new pipeline will need to be constructed.

4.6.3 Eastern Basin

The short term intervention activities for the Eastern Basin will include:

- Abstraction of AMD via pumps installed in Grootvlei No. 3 shaft at a pump depth to retain the water level beneath the ECL;
- Construction and operation of a new HDS treatment plant adjacent to the Grootvlei No. 3 shaft;
- The possible construction and operation of a waste sludge pipeline to the Brakpan, Daggafontein and/or Grootvlei TSF; and
- Construction and operation of a treated water pipeline to a suitable discharge point on the Blesbokspruit.

The short term intervention activities can, therefore, be divided into four categories:

- The abstraction of AMD from an existing shaft;
- The construction and operation of an HDS plant which will result in the discharge of neutralised water into the environment;
- The disposal and storage of the sludge produced by the HDS process; and
- The construction and operation of pipelines for transport of:
  - AMD from the shaft to the HDS plant;
  - Neutralised water to the receiving stream; and
  - Sludge from the HDS plant to the storage facility.

These activities are described in further detail below for the three basins.

4.6.4 Abstraction of AMD

The Due Diligence completed by BKS recommended that the pumps operate using a Variable Frequency Drive (VFD) to maintain the ECL within a narrow band. This will allow the water level in the basin to remain constant, with the benefit that rock containing pyrite is not periodically exposed to oxygen. By utilising a VFD the water level will remain constant and this will achieve the most cost-effective energy utilisation.

The proposed pump depth per basin will be based on the following aspects:

- The minimum depth for installation of the pumps is the ECL;
- The pumps require a minimum depth of water above the pumps (submergence depth) to prevent vortex formation and the introduction of air into the pipe system;
- The pumps should be installed at a depth to take the potential 'cone of depression' into account, i.e. the water level change along the basin; and
- The pumps should be staggered both horizontally and vertically to prevent water turbulence interaction between the pumps.

Based on the due diligence findings the following shafts will be utilised to pump the AMD:

- Shaft No. 8 – Western Basin;
- ERPM South West Vertical Shaft – Central Basin; and
- Grootvlei No. 3 Shaft – Eastern Basin.

4.6.4.1 Western Basin

Shaft No. 8 has two open conveyances. Currently one conveyance is being used to abstract water for the Rand Uranium HDS plant and this will remain in use for the duration of the immediate intervention. The second conveyance will be used for the abstraction of water for the new HDS plant at Randfontein Estates.

Two submersible pumps will be used to abstract the AMD and will be suspended from the surface. The headgear, however, will not be suitable to suspend the pumps as it is in a poor condition. It is proposed that a new gantry crane within a new steel superstructure be installed for this purpose.

The pumps will deliver a peak flow of 35 Ml/d over 24 hours and an average flow of 27 Ml/d (over an 19 hour period) and a static head of 185.2m (short term intervention). The highest pump level at which the pumps will be installed will be 1 530.1 mamsl and the pumps will be designed so the pumps can be installed to 1 500.1 m amsl, with a static head of 215.2m.

4.6.4.2 Central Basin

There is no headgear, and a new steel superstructure with gantry crane will be installed over the shaft to facilitate the installation and maintenance of the pumps.

The recommended installed pump level for flexibility with regard to the water level in the Central Basin will be 1 414 mamsl, with the pipes / pumps being designed to allow installation to 1 384 mamsl. This relates to the a pump with a maximum flow of 84 Ml/d, a best efficiency at a flow of 72 Ml/d (average, for only 19 hour pump time) and a normal static head of 209 m, with the ability to be lowered to increase the static head to 239 m and 269 m.

4.6.4.3 Eastern Basin

Borehole type, thrust balanced pumps will be suspended into the mineshaft. These pumps require minimal surface infrastructure at the shaft head and no access to the mineshaft is required during installation or operation as the pumps are lowered into the mineshaft and suspended on the pipe column.

The headgear is in very poor condition and will need to be removed, and a new steel superstructure with gantry crane will be installed over the shaft to facilitate the installation and maintenance of the pumps.

From the Due Diligence it was recommended that the installed pump level for flexibility of water level within the Eastern Basin should be 1 191 mamsl, with the pipes / pumps designed to allow the pumps to be installed to 1 134 mamsl. This relates to the a pump with a maximum flow of 110 Ml/d, a best efficiency at a flow of 106 Ml/d (average, for only 19 hours pump time) and a normal static head of 313 m, with the ability to be lowered to increase the static head to 379 m and 435 m.

4.6.5 HDS plants and discharge of partially treated water

As discussed above (section 4.6.1.1) the immediate intervention will involve the upgrade and retrofitting of the existing Rand Uranium treatment plant. The short term intervention will comprise the construction of three new HDS plants at Randfontein Estates, SWV Shaft and Grootvlei No. 3 Shaft for the Western, Central and Eastern Basins respectively.

The partially treated water will be discharged into three streams associated with the basins, shown in Plan 7. The details of the discharge points and receiving streams are summarised below.

The infrastructure required for the immediate intervention is listed below:

4.6.5.1 Western Basin

4.6.5.1.1 Immediate intervention

Neutralised water will be pumped back to the existing discharge channel and ultimately discharged into the Tweelopiespruit.

4.6.5.1.2 Short term intervention

Once treated the water in the Western Basin will be released into the Tweelopiespruit (Plan 8), which flows north into the Rietspruit before joining the Bloubankspruit. The Bloubankspruit then joins the Crocodile River, which flows into the Hartbeespoort Dam.

4.6.5.2 Central Basin

In the Central Basin the treated water will be discharged into the Elsburgspruit (Plan 9) which flows to the east of the ERPM SWV Shaft area. The Elsburgspruit flows south towards the Natalspruit which joins the Kilp River. The Klip River flows into the Vaal River above the Barrage. The discharge from the Central Basin is, therefore, entering the Upper Vaal Catchment.

4.6.5.3 Eastern Basin

Like the Central Basin the treated water from the Eastern Basin will be discharged into the Upper Vaal Catchment starting at the Blesbokspruit (Plan 10). The Blesbokspruit flows south and ultimately joins the Suikerbosrant which flows into the Vaal River.

The Due Diligence conducted by BKS noted that the impact on the receiving streams hydraulics would be negligible, with the additional discharge being factors smaller than the 1:25 flood event, as shown in Table 4-9.

Table 4-9: Hydraulic Impacts of the proposed discharge

	Western Basin	**Central Basin**	**Eastern Basin**
	Tweelopiespruit	**Elsburgspruit**	**Blesbokspruit**
1 in 25 year flood volume	28 m^3/s	96 – 182 m^3/s	429 – 600 m^3/s
1 in 100 year flood volume	37 m^3/s	125 – 237 m^3/s	543 – 761 m^3/s

	Western Basin	Central Basin	Eastern Basin
	Tweelopiespruit	Elsburgspruit	Blesbokspruit
1 in 200 year flood volume	46 m^3/s	154 – 291 m^3/s	655 – 918 m^3/s
Maximum additional discharge caused by short term intervention	35 Ml/d = 0.405 m^3/s	84 Ml/day = 0.972 m^3/s	110 Ml/day = 1.270 m^3/s
Calculated rise in flood water level	0 – 10mm	No change in water level	0 – 10mm

4.6.6 Sludge disposal and storage

Through the HDS process the AMD is neutralised. This decrease in the pH causes the precipitation of heavy metals in the form of a metal hydroxide; this forms the primary sludge stream, along with gypsum ($CaSO_4$).

It has been proposed that this sludge material be co-disposed with mine tailings and stored on existing TSF close to the treatment plants. A description of the proposed storage of the sludge is described below, in Table 4-10, for each basin.

Table 4-10: Sludge volumes and qualities per basin

	Western Basin	Central Basin	Eastern Basin
Treated Volume (Avg - m^3/day)	27 000	57 000	82 000
Sludge Volumes (Normal - m^3/day)	1 252	2 827	1 059
Sludge	15% Solids	15% Solids	15% Solids
Sulphates (mg/l)	46 480	56 455	67 737
Iron (mg/l)	20 092	20 142	28 565
Manganese (mg/l)	6 662	1 149	542
Aluminium (mg/l)	1 143	988	0
Uranium (mg/l)	3	0	0

4.6.6.1 Western Basin

It has been proposed that the sludge produced by both the immediate and short term interventions on the Western Basin be co-disposed with the tailings of Mogale Gold (Plan 11) and stored in the West Wits Pit. The West Wits Pit is currently being used by Mogale Gold to deposit tailings.

It must, however, be noted that no agreement has been reached with Mogale Gold for the use of the West Wits Pit as a storage facility for the sludge produced by the Western Basin HDS plant. It does, however, remain the preferred option.

4.6.6.2 Central and Eastern Basins

The sludge produced by the HDS plants on the Central and Eastern Basins will be stored on an existing TSF.

Sludge produced in the Central Basin will first be pumped to the DRD Gold Crown Knights Gold Plant, 3 km northeast of the SWV Shaft, before being blended with their tailings and pumped to the Brakpan TSF (Plan 12).

In the case of the Eastern Basin the sludge will be pumped via pipeline to one or a combination of the Brakpan, Daggafontein and/or Grootvlei TSFs (Plan 12).

It must, however, be noted that no agreement has been reached with DRD Gold for the use of the Brakpan TSF as a storage facility for the sludge produced by the Central Basin. Furthermore no agreement has been reached with DRD Gold for the use of the Brakpan and/or Daggafontain TSFs for the co-disposal of the sludge produced on the Eastern Basin. No agreement has been reached with Grootvlei (or the liquidators thereof) for the use of the Grootvlei TSFs for the co-disposal of the sludge produced on the Eastern Basin.

4.6.7 Construction and operation of pipelines

A number of pipelines will be constructed for the immediate and short term interventions. The pipelines will be used to transport the AMD, abstracted from the shafts, to the treatment plants. Pipelines will also be constructed to discharge the treated water into the receiving streams, while, other pipelines will be used to carry the sludge produced by the treatment process to the proposed storage facilities. The pipeline routes, specifically for the sludge transport, are yet to be defined. It is, however, suggested that areas or routes suitable for the construction of the pipelines are determined during the EIA process.

Details of the pipelines to be constructed for the immediate and short term intervention, as proposed thus far, are given below and the general routes, where available, are shown on Plans 4, 5 & 6.

4.6.7.1 Immediate and Short Term Western Basin

The pipeline infrastructure already in place at the Rand Uranium treatment plant will be used. This includes a pipeline from Shaft No. 8 to the treatment plant as well as a treated slurry pipeline to the CPS pit, where clarification will take place. A pipeline from the CPS Pit to the West Wits Pit has to, however, be constructed.

A 2.7km pipeline (0.7m diameter) from Shaft No. 8 to the Western Basin HDS plant will be constructed to transport the abstracted AMD. The pipeline for the treated water discharge, 0.6m diameter, will be constructed above ground and will be approximately 6.8 km in length. It has been proposed that the pipeline crosses the R28 and go beyond the Hippo Pool in the Krugersdorp Game Reserve to prevent ingress of neutralised water into the mine void and recharge. The sludge pipeline, a 0.2m diameter, 4.2 km long above ground pipeline, will be constructed from the HDS plant to the West Wits Pit.

4.6.7.2 Central Basin

The pipeline infrastructure on the Central Basin will not be excessive due to the abstraction point and the treatment plant being on the same site. A short (100m) pipeline of a 0.55 m diameter will be constructed to take the AMD water to the treatment plant. The treated water will then be discharged into the Elsburgspruit via a 1.05m diameter, 1.5km long pipeline. This pipeline will follow an existing servitude from the treatment plant to the Elsburgspruit.

It has been proposed that two above ground sludge pipelines be constructed to the DRD Gold Crown Knights Gold Plant. The pipeline route will be approximately 3.8km to the Knights Gold Plant. In so doing the pipeline will cross a railway line twice (one single crossing and one double crossing) as well as Tide Street and the R29, where pipe jacking will take place. It is envisaged that existing pipelines will be used from the Knights Gold Plant to the Brakpan TSF, however, this has not yet been agreed upon.

4.6.7.3 Eastern Basin

The pipeline infrastructure on the Eastern Basin will not be excessive due to the abstraction point and the treatment plant being on the same site. A short (100m) pipeline of a 1.05 m diameter will be constructed to take the AMD water to the to the TSF site have yet to be decided. The use of the Brakpan, Daggafontein and/or the Grootvlei TSFs has not been decided and thus the pipeline routes cannot be defined. It is proposed that suitable routes are identified during the EIA studies for these pipelines.

5 PROJECT ALTERNATIVES

Technological and site layout alternatives for the proposed immediate and short term interventions were identified as part of the Scoping Phase. The “no-go” option (no intervention) was also investigated.

5.1 Treatment technology alternatives

The first phase of treatment technology selected by BKS, following on the recommendations of the Team of Experts, has been the neutralisation and HDS treatment route. It was chosen due to its large scale application around the world for problems of this nature. It is also the treatment technology which was being used by ERPM and Grootvlei to date. This processing route has many potential small modifications to it such as the use of different neutralising agents. It may be possible to use other alkalis such as only lime, sodium carbonate, or sodium hydroxide. The cost however has precluded their use on a large scale for this type of application.

The main process alternative to be considered is why the full scale processing or final treatment was not implemented at this stage. The reasons why it was not recommended as part of the immediate and short term treatment options are that:

- It is expensive and a mechanism must be found as to whom is going to pay for this treatment and how it is going to be performed;
- Institutional arrangements have to be put in place to manage the operation of these facilities and the water resulting from these facilities;
- The construction takes time and something needed to be done as a matter of urgency;
- The standards to which the water should be treated had not yet been decided. It could be to potable standards, industrial standards or for discharge into a stream; and
- Different technologies need to be considered for the different areas.

The list of technology alternatives considered by the Team of Experts and their applicability to the different basins is given in Appendix E.

As stated previously, the long term solution is being investigated as part of another project.

5.2 Abstraction alternatives

5.2.1 ECL

There are questions as to what the optimal ECL is in each basin. Obviously the deeper the water level is kept the more pumping costs are and possibly the more water ingresses into the system. The optimal level needs to be presented in the final EIA report.

In the Eastern and Western basins the idea is to keep the water level below the level of surrounding dolomite compartments and thus ensuring that water flow is always towards the mine workings from these dolomites. This does ensure that the dolomites are not contaminated, however, it does mean that this uncontaminated water will be drawn towards the abstraction points from the dolomites and pumped out as poor quality water.

In the Central basin the aquifers affected are very closely correlated to the reef and do not extend far from the mining areas. This has been confirmed over years as the cone of dewatering is very close to the workings. The ECL is thus more decided on the level to which the groundwater needs to be kept throughout the whole basin as the same level would be found from west to east. At present the ECL has been chosen to be below the floor level of the Gold Reef City underground tour area.

For the Western basin there are a number of important determining levels.

The Hippo Pool is at 1 636 mamsl. The entrance onto Zwartkops compartment is 1 530 mamsl. This is why it has been set it at this level. The bottom of the dolomitic outlier in this area is at 1 570-80 mamsl.

5.2.2 Central Basin - position of dewatering pumps

There have been suggestions that the position of the dewatering pumps needs to be investigated as it may be better to place the pumps or abstraction point nearer the outcrop area to ensure that water quality improves sooner and to prevent highly saline water being drawn from the deeper workings over time. The deeper shafts could act as boreholes into the deeper reaches of the basin and thus poorer quality water could be drawn in as poorer quality of water is expected in the deeper parts of the mine.

Different shafts could also be considered based on the fact that some shaft areas may have more functioning infrastructure than others.

5.2.3 Reducing inflow into the mine workings

This could be achieved in a number of ways but the two categories of prevention could be preventing direct ingression e.g. by preventing surface streams from entering underground workings and secondly by pumping water from aquifers connected to the workings, particularly where there are dolomites. This water should theoretically be cleaner and could be used or discharged. This could be achieved by installing boreholes into the dolomites of the Western and Eastern Basins.

Surface streams could be looked at in areas such as the Blesbokspruit where the water flows over dolomitic areas or areas such as the outlet to Florida Lake where remedial work has already been started.

These items need to be investigated but do not directly form part of this project.

5.3 Sludge disposal alternatives

A number of people have questioned the optimal disposal position for the sludge. In addition to the options proposed there may be alternatives to place the sludge into specially designed and sealed disposal facilities. These will have to be designed such that they can be sustainably closed after operation.

There is also the opportunity to place the sludge on top of unused tailings facilities as this will ensure that geotechnical conditions are understood and that no additional surface area is disturbed.

These items need to be investigated but do not directly form part of this project.

5.4 Treated water discharge alternatives

5.4.1 Water users

There have been a number of suggestions that various companies may be interested in purchasing the water rather than allowing it to discharge directly into the water courses. Whilst the water could be used for reclamation of tailings materials or pumped to other catchments for use such as the platinum mines, however, the amounted needed by the mines and the amounts available need to be determined. The economic cycles of projects often do not correspond with the need to discharge.

This aspect should however be investigated in a lot more detail. It may be very beneficial to link this project to a pipeline to areas or operations requiring water of this type of quality. This would also alleviate the need to treat the water to a potable condition.

It is likely that this will be investigated further by the project team investigating the long term solution.

5.4.2 Discharge point on the Western Basin

It has been suggested by some parties that an alternative to disposing of the water into the Tweelopiespruit needs to be investigated. One possibility would be to discharge the treated water into the Wonderfonteinpruit. This water will then enter the Vaal catchment instead of the Crocodile catchment.

This option needs to be investigated in more detail. There is apparently some initial resistance to the idea of introducing another load of salts into the Vaal river system by the DWA. There is also a concern that some of the water from the Loopspruit may re-enter the groundwater regime over dolomitic ground. There is a pipeline which has been constructed over the dolomitic ground which apparently is running quite full and which would not be able to deal with the additional flow. The pipeline starts at the Peter Donaldson Dam.

6 CURRENT STATUS OF THE ENVIRONMENT

This Chapter provides a description of the status of the biophysical, socio-economic and cultural environment of the three proposed project sites as well as those that are influenced by the project.

Further assessments will be undertaken during the EIA Phase to deepen the understanding of the receiving environment and ensure all impacts are managed accordingly.

6.1 Socio-Economic environment

6.1.1 Study area

6.1.1.1 Western Basin

The watercourse constituting the study area in the Western basin runs primarily from south to north. The proposed water treatment plant will decant into the Tweelopiespruit, which runs for about 5 km, mostly through the Krugersdorp Game Reserve on the western outskirts of Krugersdorp (Mogale City) before flowing into the Rietspruit soon after passing under the N14 highway. From this point the average stream flow sometimes flows underground and sometimes on surface.

The Rietspruit flows into the Bloubankspruit and continues northwards for 60 km before flowing into the Hartbeespoort Dam. At first, it runs parallel to the N14 for 3 km, then passes through a stretch of land dominated by farms, small holdings and a number of hospitality venues (Greensleeves Restaurant, the Maikiti Wedding Venue, Kanjara Lodge) and nature reserves (the Rhino and Lion Nature Reserve, Aloe Ridge Hotel and Game Reserve and Heia Safari Ranch). It then runs under the R512 highway and passes Lanseria, Blair Atholl Golf Estate and the town of Hartbeespoort before entering Hartbeespoort Dam at Port d'Afrique.

6.1.2 Central Basin

The watercourse constituting the study area in the Central basin runs primarily from north to south. The proposed treatment plant for the Central basin will decant into the Elsburgspruit, which runs for some 7 km, through Germiston South, close to Kutalo Station, past Martin du Preezville, and passes under the N17 highway before flowing into the Natalspruit.

The Natalspruit flows for about 75 km before joining with the Vaal River at Vereeniging. It flows between Elspark (to the east) and the industrial area of Wadeville (to the west), past Klippoortjie Agricultural Holdings and Roodekop before flowing under the R103 and the N3 highway. It then runs between Tshongweni township (to the west) and Spruitview (to the east), Mosekele East (on the west) and Vosloorust (on the east), past Ke-Ditselana Tourism Multicultural Village, and between Ap Khumalo and Moleleki townships (to the west and east, respectively). For a stretch of about 4 km, the river's banks are then characterised by fairly intense subsistence farming by neighbouring communities (Palm Ridge to the west and Zonkizizwe to the east).

It then flows under the R550, passes through a stretch of land characterised by commercial agriculture with pivot irrigation, past Gardenvale Agricultural Holdings, Witkopdorp (Daleside), Henley on Klip, Meyerton and Rothdene, and runs parallel to the Sybrand van Niekerk Freeway for a short stretch before entering Vereeniging where it joins with the Vaal River.

The part of the study area constituted by the Vaal River covers about 30 km. After leaving Vereeniging, it passes Duncanville, Vanderbijlpark, the Emerald Casino Resort, Abrahamsrust and Marlbank River Estate.

6.1.3 Eastern Basin

The watercourse constituting the study area for the Eastern basin also runs predominantly north to south. Its first part, with a length of about 58 km, is the Blesbokspruit. It starts just to the south of the N17 highway and, after a short stretch flanked by agricultural land with pivot irrigation, passes Strubenvale, Daggafontein, Marievale to the west and more commercial farming to the east. It then flows under the R42 (the Nigel-Marievale road) before flowing past Vosterkroon, Nigel, Laversburg, Alra Park and Jameson Park in Heidelberg. At Heidelberg, it flows under the N3 highway, after which it passes Shalimar Ridge, Ratanda and more commercial farms before joining the Suikerbosrant.

The final part of the study area extends for some 50 km before it joins with that of the Central basin at Vereeniging. It passes a stretch of land dominated by commercial farms, passes under the R54, than passes Helderstrome Agricultural Holdings, Van der Westhuizenhoogte Agricultural Holdings and Three Rivers East before joining the Vaal River at Vereeniging.

6.2 Land use

The socio-economic impacts of the project are expected to arise mainly from potential changes in the quantity and quality of water in the watercourses constituting the study area. Consequently, accurate assessment of these impacts will rely heavily on accurate information regarding water uses and riparian land uses along these watercourses.

This section, therefore, presents a preliminary assessment of land uses along the three watercourses representing the study areas for the Western, Central and Eastern basis, respectively. These land uses were identified by means of visual inspection of available satellite imagery, concentrating on a strip of land extending 500 metres to either side of the relevant watercourse.

Land uses within this strip were classified into seven types:

- Industrial;
- Medium- to high-density residential (townships, suburbs, etc.);
- Low-density residential (golf estates, etc.);

- Smallholdings;
- Commercial agriculture;
- Subsistence agriculture; and
- Land on which there is little or no evidence of human occupation.

Examples of each of these land use types are given in Table 6-1 below.

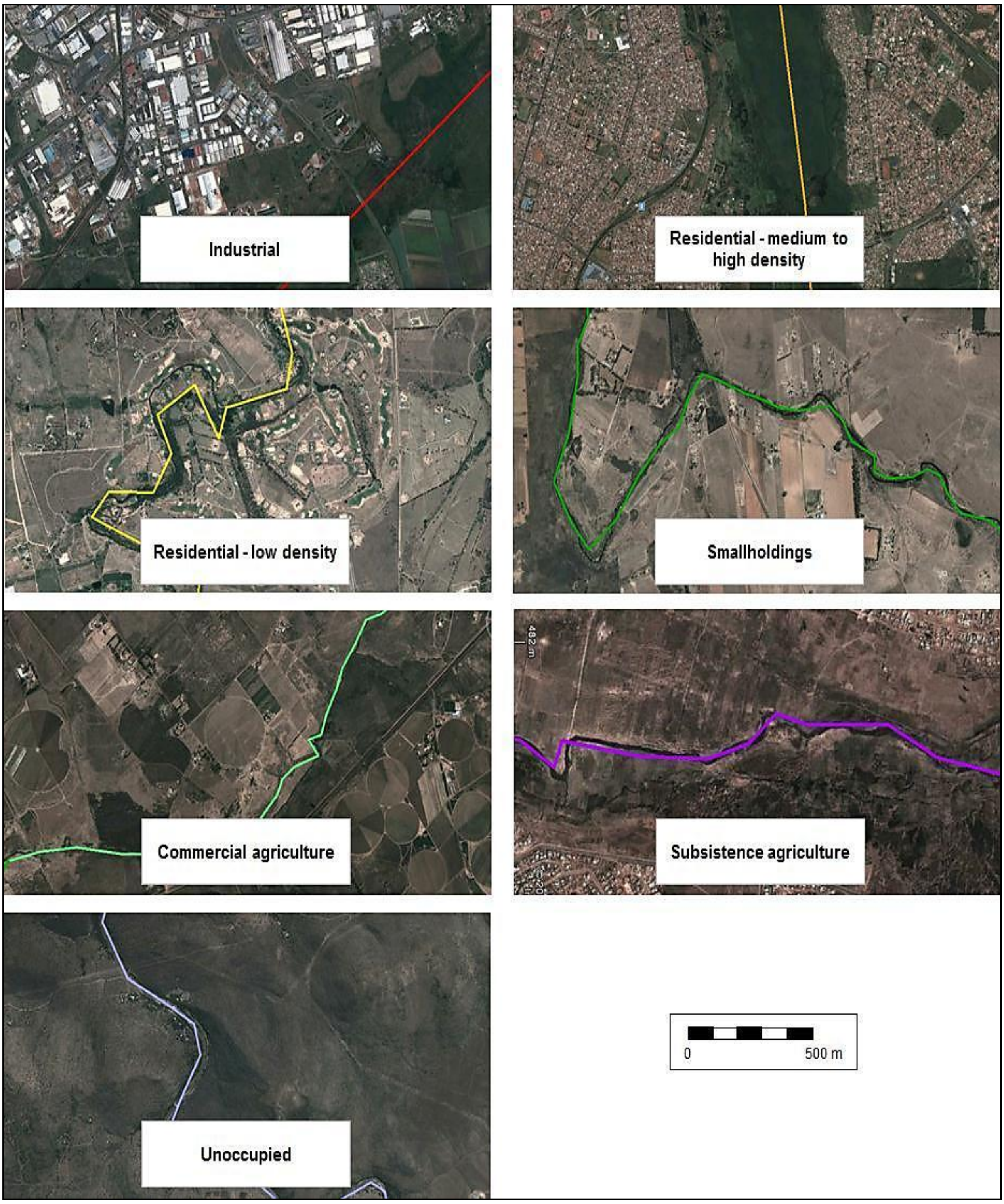

Table 6-1: Examples of land use types

The resulting characterisation of the three watercourses constituting the study area is shown in Table 6-2. The length and proportion of each watercourse that is adjoined by the various land use types is given in Table 6-3 and graphically depicted in Table 6-4.

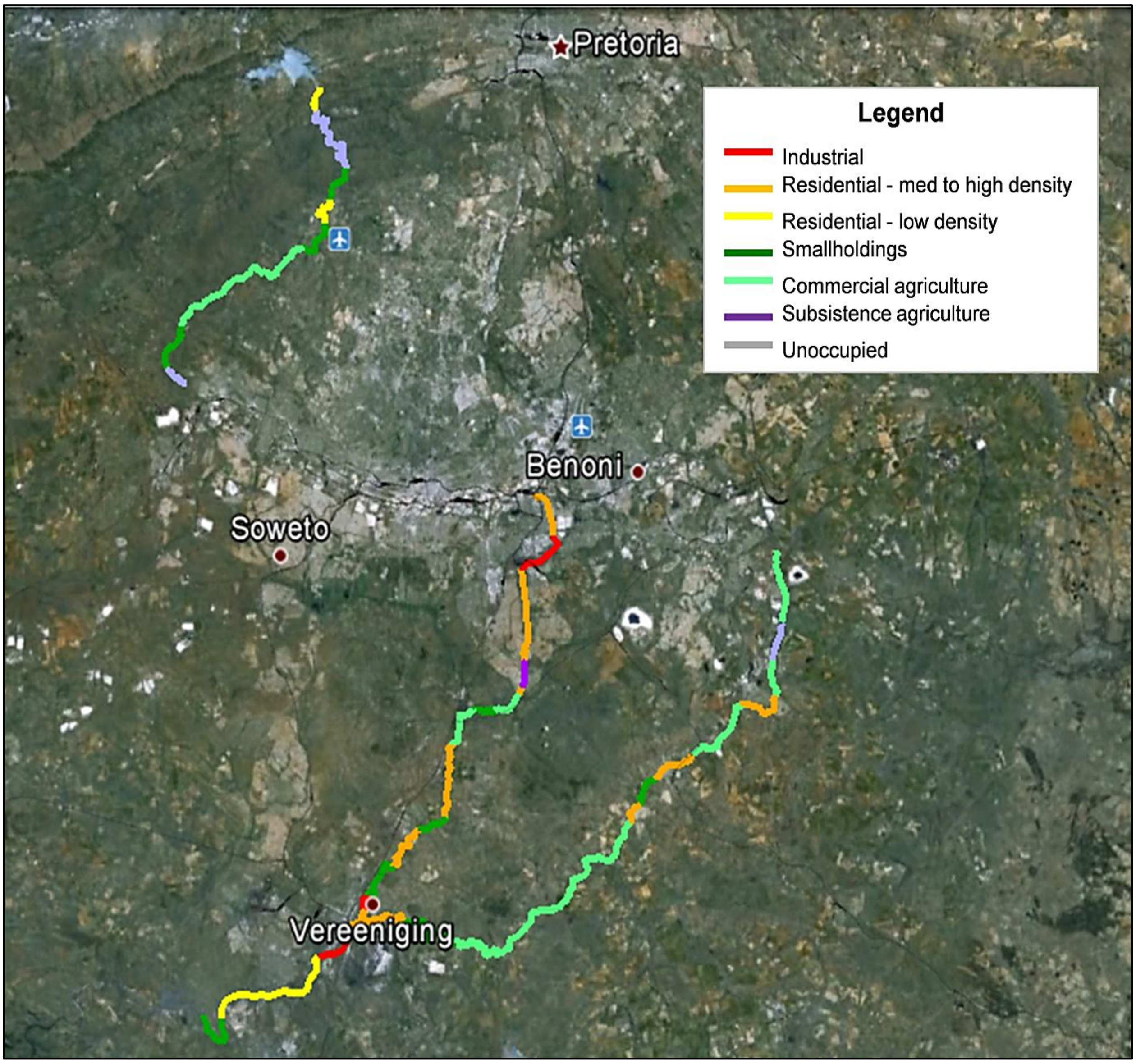

Table 6-2: Characterisation of the study area in terms of land use

Table 6-3: Lengths of potentially-affected watercourses adjoined by each land use type

Land use type	Western Basin	Central Basin	Eastern Basin	All
Commercial agriculture	22 km *(34%)*	11 km *(10%)*	65 km *(60%)*	98 km *(34%)*
Industrial	-	16 km *(14%)*	-	16 km *(5%)*

Land use type	Western Basin	Central Basin	Eastern Basin	All
Residential - low density	9 km *(14%)*	18 km *(16%)*	-	27 km *(9%)*
Residential - med to high density	-	40 km *(36%)*	23 km *(21%)*	63 km *(22%)*
Smallholdings	18 km *(27%)*	24 km *(21%)*	15 km *(14%)*	57 km *(20%)*
Subsistence agriculture	-	4 km *(3%)*	-	4 km *(1%)*
Unoccupied	16 km *(25%)*	-	5 km *(4%)*	21 km *(7%)*
Total	**65 km *(100%)***	**112 km *(100%)***	**108 km *(100%)***	**285 km *(100%)***

As can be seen from the aforementioned table and figure, the western watercourse is the only one flowing through a significant stretch of unoccupied land, with the remainder being occupied by commercial agriculture, smallholdings and (to a lesser extent), low-density residential areas.

The central watercourse is the only one flanked by an appreciable stretch of industrial area, as well as by some subsistence agriculture, with the remainder being occupied mainly by medium- to high-density residential areas, smallholdings and low-density residential areas.

The eastern watercourse flows mostly through areas dominated by commercial farming, with the remainder of its length being flanked by medium- to high-density residential areas and smallholdings.

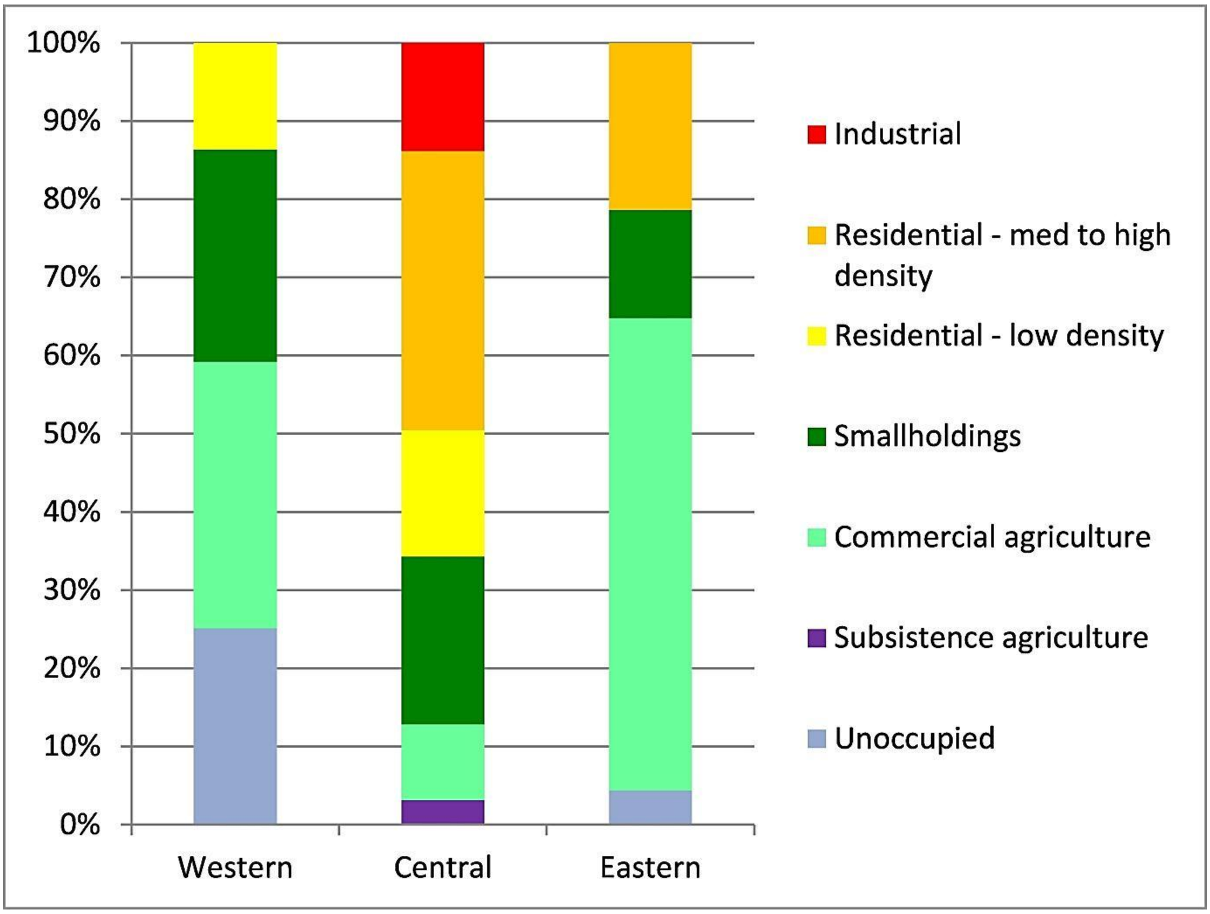

Table 6-4: Proportion of the three watercourses adjoined by each land use type

6.3 Socio-economic characteristics of the study area

This section provides a preliminary overview of the socio-economic characteristics of the wider community within the project areas. This overview was developed on the basis of available secondary data – in particular, Census 2001 statistics. It is acknowledged that conditions may have changed in the intervening years since 2001; this information will, therefore, have to be updated during the impact assessment phase of this study, either by means of primary data collection or through the results of the 2011 census (depending on availability).

The Census 2001 statistics presented in this section have been aggregated in terms of municipal wards, using the ward delineations that were in effect in 2001. These wards, together with the local or metropolitan municipalities and the provinces to which they belong, are listed in Table 6-5 and illustrated in Plan 13, Plan 14 and Plan 15.

The remainder of this section contains a quantitative profile of these wards based on the demographic characteristics of their resident communities, the education levels of these communities, employment statistics, housing, and access to services and infrastructure.

Table 6-5: Municipal wards traversed by the potentially affected watercourses

Watercourse	Province	Municipality	Ward
Western (from south to north)	Gauteng	Randfontein	8 4 2 1
		Mogale City	18
		West Rand District Management Area	N/A
	North West	Madibeng	28
Central (from north to south)	Gauteng	Ekurhuleni	33 32 36 34 22 28 23 26 25
		Midvaal	4 3 2
		Emfuleni	1 4 6 26
	Free State	Metsimaholo	13 14 16
Eastern (from north to south)	Gauteng	Ekurhuleni	61 60 88
		Lesedi	6 7 8
		Midvaal	1

6.3.1 Western Basin

Communities along the southernmost parts of the watercourse (Randfontein Municipality Wards 8 and 4) are mostly Afrikaans-speaking (either White or Coloured), with fairly high education and high employment levels (at least among the Afrikaans-speaking community), with most employment being in the community services and wholesale/ retail sectors. These communities are characterised by moderately high income levels. Access to water and sanitation services is relatively high, with most households having flush toilets and piped water in the dwelling.

Slightly further to the north (in Randfontein Municipality Wards 2 and 1), communities are mostly African and Setswana-speaking with lower formal education levels than their southern neighbours. Unemployment is higher than in the White and Coloured communities further south, and income levels are lower. Levels of water and sanitation services are also lower, with some communities relying on piped water in the yard (as opposed to in the dwelling) or community standpipes, and having pit latrines rather than flush toilets. Agriculture represents one of the main sources of employment in these wards

These characteristics are also reflected in the communities further north (Ward 18 of Mogale City and Ward 28 of Madibeng Municipality). However, underdevelopment is more pronounced in the northernmost of these wards, with many households living in informal dwellings, having limited access to water and sanitation services, and low income levels.

6.3.2 Central basin

Wards along the northern part of the watercourse fall into two main categories. Firstly those (Ekurhuleni Wards 22, 28, and 25) which are mostly White or Coloured, Afrikaans- or English-speaking communities with relatively high education, employment and income levels. The economy in these communities is fairly mixed, with most economic sectors contributing to employment, and access to water and sanitation services are good.

These are interspersed with the second category of communities (Ekurhuleni Wards 33, 32, 36, 34, 23 and 26) that have several contrasting characteristics: their population is mostly African, Zulu- or Sesotho-speaking, with fairly low education levels, low employment rates and low incomes. Some of these (particularly in Ekurhuleni Wards 23 and 26) live in informal settlements with limited access to water and sanitation services. Employment in these wards is mostly in the manufacturing and community services sectors.

Further to the south (in Midvaal Municipality Wards 4, 3 and 2, and Emfuleni Municipality Wards 1 and 4), communities tend to be more affluent, with higher education and employment levels (manufacturing being one of the largest sources of employment).

At the last part of the watercourse, a clear contrast is evident between communities on its northern side (Emfuleni Municipality Wards 6 and 26) and those to its south (Metsimaholo Municipality in the Free State Province, Wards 13, 14 and 16). The northern communities are mostly African, Sesotho-speaking, with low education, employment and income levels (most being employed in the wholesale/retail and agricultural sectors), while those to the south are mostly White, Afrikaans-speaking, with high education, employment and income levels (the manufacturing sector being the dominant source of employment).

6.3.3 Eastern basin

Communities along this watercourse can again be grouped into two main categories. Those (Ekurhuleni Wards 61, 60 and 88, Lesedi Ward 8 and Midvaal Ward 1) which are mostly African, Zulu-speaking, with fairly low education levels, low employment rates and low incomes. Some of these (particularly in Ekurhuleni Ward 61 and Lesedi Ward 8) live in informal settlements, and in most of these communities, access to water and sanitation services is limited. These are interspersed (in Lesedi Wards 6 and 7) with the second type, the more affluent communities that are mostly White and Afrikaans-speaking, with relatively high education, employment and income levels. The dominant sources of employment are community services and agriculture.

6.4 Cultural and heritage characteristics

The current cultural and heritage landscape within which the AMD project will take place can in essence be divided into two categories – industrialised and rural. Primary activities will take place within the industrialised landscape; however, activities may trigger impacts on heritage resources within the more rural landscape. This industrialised landscape essentially comprises sites, places, and structures related to the industrial development and history of the Witwatersrand. The history of mining has to a considerable degree driven and shaped the character of this landscape. Tangible or physical representations of this include structures associated with early operations and other remnants of the historical built environment and sites or places related to migrant labour to consider some aspects. Intangible facets such as the socio-political history must also be considered. Fundamentally, the current heritage landscape is a historical one, except for that of the Cradle of Humankind World Heritage Site (COH WHS).

6.4.1 Western Basin

6.4.1.1 General receiving heritage landscape

Compared to the Central and Eastern Basins, the Western Basin is less industrialised, and the general landscape not shaped by mining to the same extent. Predominant industrial and urban areas are found in Krugersdorp to the east and Randfontein to the south. Large areas north and west comprise agricultural properties interspersed with several nature reserves and natural areas, most notably the COH WHS. The general heritage landscape is, therefore, much more layered and complex than compared to the above landscapes discussed, including historical, archaeological, and palaeontological heritage resources.

The area was first developed during the discovery of gold on the Witwatersrand. Before Krugersdorp was established in 1887 as a result of increased mining on the West Rand, the area was mostly farm land. Several battles and skirmishes also occurred in the area, during the First and Second Anglo-Boer Wars, and a concentration camp associated with the latter war was also formed in 1901 near Krugersdorp. Remnants of this aspect of the historical landscape may include graves, battlefields, historical homestead complexes, and other structures, as well as subsurface evidence such as middens.

Another important aspect that should be considered in characterising the historical landscape is various old limestone mines and kilns, in operation during the late 1800s. Examples of these structures are found in protected areas such as the Krugersdorp Game Reserve and elsewhere. More recently, socio-political heritage includes dispossessed landscapes. Many black families and communities were forcibly removed from land they occupied, especially from 1960 onwards. Some intangible aspects that should also be considered can include historical initiation sites, of which at least one has been previously recorded.

The area can also be characterised by episodes related to the *Difeqane*. This was a period of massive population displacement throughout South Africa caused by the Matabele (Ndebele) raiding parties of Mzilikazi who violently migrated from present northern KwaZulu-Natal from the last decade of the 18th century. Mzilikazi conquered the BaPo (one of several original Tswana occupiers of the region) in the early 1800s and then settled in the area. When the first white *Voortrekkers* arrived during the 1830s, they in turn drove Mzilikazi out. Several of *Difeqane* refuge sites are scattered in the landscape, as well as some of the Matabele settlements. Evidence of earlier Iron Age occupation and settlement also occur, although very little is known regarding Early Iron Age sites and settlements. The most prominent and visible site type is stonewalled sites that predate the *Difeqane*. These are predominantly associated with Sotho-Tswana-speaking groups (known as Type N and Klipriviersberg sites), the relative date range for these being 1400 to 1800.

6.4.1.2 Immediate receiving heritage landscape

The proposed project area can be characterised as a relatively recent industrial landscape with archaeological and historical elements possible. The Randfontein Estates Gold Mining Company was formed in 1889. In 1952 they successfully applied as a uranium producer, and the first uranium processing plant commissioned in 1954. Compared to the Central and Eastern Basin sites due to the relative open nature of the surrounding environment, other heritage resources occur that should be considered in characterising the immediate receiving environment. These include burial grounds (informal and Boer War associated), Iron Age stonewalling sites, early Voortrekkers settlements, and Stone Age locales.

Arguably, the most important perceived heritage landscape is the COH WHS and includes the fossil hominid sites of Sterkfontein, Kromdraai, Swartkrans, and the newly discovered Sediba site. Other than representing human evolution and at least the Early and Middle Stone Ages, the COH WHS also contain historical resources such as the above mentioned lime kilns. The COH WHS will be discussed in more detail below.

6.4.2 Cradle of Humankind World Heritage Site

The fossil hominid sites of Sterkfontein, Swartkrans, Kromdraai and environs were inscribed for protection of their cultural heritage in 1999 in terms of the World Heritage Convention Act (Act No. 57 of 1999) (WHCA). These sites are collectively known as the Cradle of Humankind World Heritage Site (location shown in Plan 16). The COH WHS was inscribed by the UNESCO World Heritage Committee (WHC) in 1999 and 2005 as summarised in Table 6-6 below. At the 34th session of the WHC held in Brasilia, Brazil from 25 July to 3 August 2010, a draft decision (Document WHC-10-34.COM/8E.Add2) was presented to the committee. The WHC adopted the retrospective Statement of Outstanding Universal Value

(SoOUV) for the COH WHS. The 'brief synthesis' of the SoOUV has been replicated in the information box below.

Table 6-6: Official UNESCO description of COH WHS

Property	Fossil Hominid Sites of Sterkfontein, Swartkrans, Kromdraai, and Environs
State Party	South Africa
Id. N°	915 bis
Dates of inscription	1999 / 15th July 2005

6.4.2.1 Criteria defining Outstanding Universal Value

The SoOUV is based on UNESCO's Operational Guidelines for the Implementation of the World Heritage Convention (2005). Two criteria were specifically considered.

1) Criterion (iii)

According to the Operational Guidelines (2005) sites complying with Criterion (iii) must bear a unique or at least exceptional testimony to a cultural tradition or to a civilisation which is living or which has disappeared.

In the retrospective SoOUV the COH WHS was considered to comply with this criterion as it '*bears exceptional testimony to some of the most important Australopithecine specimens dating back more than 3.5 million years. This therefore throws light on to the origins and then the evolution of humankind, through the hominisation process*'.

2) Criterion (vi)

According to the Operational Guidelines (2005) sites complying with Criterion (vi) should be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance.

The retrospective SoOUV considered the COH WHS to comply with this criterion as '*the serially nominated sites are situated in unique natural settings that have created a suitable environment for the capture and preservation of human and animal remains that have allowed scientists a window into the past. Thus, this site constitutes a vast reserve of scientific data of universal scope and considerable potential, linked to the history of the most ancient periods of humankind*'.

Information Box 1: Summarised description of COH WHS Statement of Outstanding Universal Value

The undulating landscape containing the fossil hominid sites of South Africa comprises dolomitic limestone ridges with rocky outcrops and valley grasslands, wooded along watercourses and in areas of natural springs. Most sites are in caves or are associated with rocky outcrops or water sources. The serial listing includes the Fossil Hominid Sites of Sterkfontein, Swartkrans, Kromdraai and Environs, and the Makapan Valley and Taung Skull Fossil Site. The Taung Skull, found in a limestone quarry at Dart Pinnacle amongst numerous archaeological and palaeontological sites south-west of the Sterkfontein Valley area, is a specimen of the species Australopithecus africanus. Fossils found in the many archaeological caves of the Makapan Valley have enabled the identification of several specimens of early hominids, more particularly of Paranthropus, dating back between 4.5 million and 2.5 million years, as well as evidence of the domestication of fire 1.8 million to 1 million years ago. Collectively these sites have produced abundant scientific information on the evolution of modern humans over at least the past 3.5 million years. They constitute a vast reserve of scientific information, with enormous potential.

The sites contain within their deposits all of the key interrelated and interdependent elements in their palaeontological relationships. Alongside and predating the hominid period of occupation is a sequence of fossil mammals, micro-mammals and invertebrates which provide a window onto faunal evolution, palaeobiology and palaeoecology stretching back into the Pliocene. This record has come to play a crucial role in furthering our understanding of human evolution and the appearance of modern human behaviour.

The fossil evidence contained within these sites proves conclusively that the African continent is the undisputed Cradle of Humankind.

6.4.2.2 Integrity and authenticity of COH WHS

In addition to the criteria outlined above, the SoOUV has also taken into account the COH WHS's integrity and authenticity as defined in the 2005 Operational Guidelines.

The SoOUV concluded that the integrity of the COH WHS (as well as the Makapan Valley and Taung Skull Fossil Site) is provided due to its location in three provinces (Gauteng, Northwest, and Limpopo Provinces) and gazetted buffer zone for each component. The COH WHS, Makapan Valley, and Taung Fossil Site significantly contributed to an extensive body of scientific knowledge concerning human evolution spanning 3.5 million years. The distribution of the inscribed properties furthermore represents a great reservoir of potential scientific information.

The SoOUV determined that the sites authenticity is apparent in the fundamental interrelated and interdependent elements of natural palaeontological relationships. Accordingly the deposits represent a sequence of palaeo-ecosystems. The breccia contains fossilised remains of hominids and their lithicultural material, other faunal and botanical fossils and geochemical and sedimentological data describing relevant taphonomic conditions of each geological member or strata. The sites and deposits that have yielded material in addition to the landscape are still considered to be generally intact. However, each site and landscape is considered to be vulnerable to development pressures, communities' use of the environment and tourism.

6.5 Ecological environment

6.5.1 Provincial biodiversity planning

According to the Gauteng C-plan 3 the Gauteng province is categorized into seven biodiversity conservation categories for terrestrial ecosystems using systematic biodiversity planning methods. In Table 6-7 one can see the seven categories.

The main threat to natural areas/biodiversity is the reduction of viable habitat, which can be contributed to the following, human settlement and urban development, mining, industry and manufacturing, energy, transport, agricultural activities and tourism and recreation. All of the above with the possible exception of tourism and recreation are currently exerting pressure on the study area (area in general) by reducing the viable natural land. The 'No natural habitat remaining' is the category in which most threats can be categorized, and the transformation of the natural habitat from Protected Areas to No Natural Habitat remaining is driven by the seven threats.

Table 6-7: Gauteng C-Plan 3 categories

Category
Protected Areas
Irreplaceable
Highly Significant
Ecological Support
Important and necessary
Least concern
No Natural Habitat Remaining

Each category represents a different sensitivity rating. These ratings are specific as to which areas are to be conserved for biodiversity maintenance. The receiving rivers have been classified by the sensitivity ratings above and shown in Plan 17.

6.5.2 Regional natural environment

The study areas fall in the Grassland Biome that is found mainly on the high central plateau of South Africa, and the inland areas of KwaZulu Natal and the Eastern Cape (Table 6-8), the study area is indicated on the map as a red dot.

Trees are absent, except in a few localised habitats and geophytes are often abundant (Low & Rebelo, 1996). Sour grassland occurs in the high rainfall eastern grassland regions (average rainfall >625 mm/annum), on relatively acidic (leached) soils (refer to soils section), and is characterized by being short and dense in structure, having a high fibre content and a tendency to withdraw its nutrients from its leaves to its roots during the winter, rendering it largely unpalatable to stock during this time.

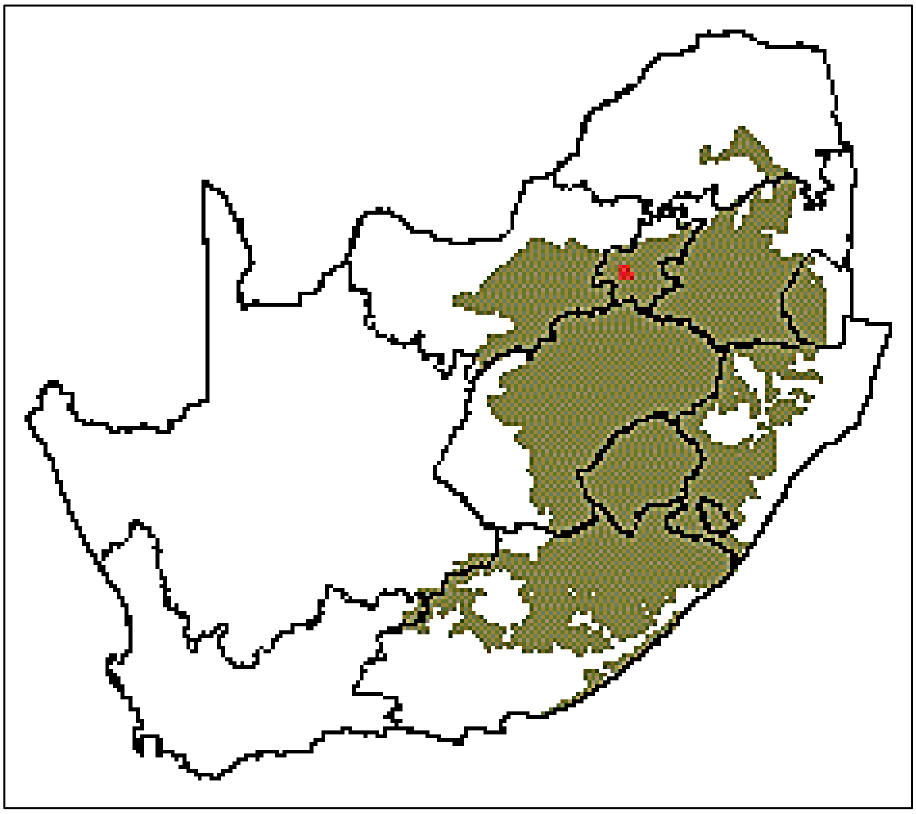

Table 6-8: Grassland Biome of South Africa and project sites

Of the 72 vegetation types in the biome, 2 are listed as critically endangered, 18 are endangered and 27 are classed as vulnerable. 83% of river ecosystems are ranked as threatened, with 48% critically endangered.

6.5.2.1 Terrestrial flora bioregions

According to Mucina and Rutherford (2006), a Bioregion is a composite spatial terrestrial unit defined on the basis of similar biotic and physical features and processes at the regional scale.

The Dry Highveld Grassland prevails in the western regions of the Grassland Biome where annual rainfall is below 600mm/a. These grasslands are therefore sweet grasslands. This grassland type is mostly plains grassland distinguished primarily on substrate characteristics (Mucina and Rutherford 2006). The Carltonville Dolomite grassland vegetation type is found in this bioregion.

Mesic Highveld Grassland is mostly found within high rainfall areas of the Highveld, extending as far as the northern escarpment. These are sour grasslands and are dominated mostly by Adropogonoid grasses (Mucina and Rutherford 2006). The Soweto Highveld grasslands and the Tsakane Clay grassland vegetation types are found within this bioregion.

6.5.2.2 Wetland bioregions

Azonal Fresh water wetlands form a system of small and highly fragmented patches, embedded within all mainland biomes, including the grassland biome. These are common landscape features in regions with a mean annual rainfall of 500 to 600 mm/a. These typical freshwater wetlands are vleis that form in the catchment areas of Highveld streams, where a sufficient shallow gradient permits the soil to be wet without being eroded by flow of water (Mucina and Rutherford 2006).

Eastern Temperate Freshwater Wetlands that are found in each of the three basins fall within this azonal fresh water wetland description. These areas are the areas that will be directly affected by the discharge.

It is expected that most wetlands in the study area that have the potential of being impacted, are valley bottom and floodplain wetlands. Unchannelled valley bottom wetlands may occur, but these will have to be confirmed during the surveys.

Unchanneled valley bottom wetlands are uncommon and it these do occur in the sphere of influence and discharge runs the risk of increasing erosion, head cuts and channelling this would have to form a major focus of the investigations.

Additionally, potential changes in riparian and wetland macrophytes need to be monitored and assessed. If for example, conditions are going to increase the spread of *Typha* at the cost of other obligatory hydrophytes such as *Phragmites* or *Schoenoplectus,* mitigation measures for this aspect will have to be worked into a management plan for the project but also into the management plan for the Ramsar site (Eastern Basin) and other wetland management areas.

6.5.2.2.1 <u>Ramsar sites</u>

The Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Negotiated through the 1960s by countries and non-governmental organizations that were concerned at the increasing loss and degradation of wetland habitat for migratory waterbirds, the treaty was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. It is the only global environmental treaty that deals with a particular ecosystem, and the Convention's member countries cover all geographic regions of the planet.

6.5.2.3 Vegetation units

6.5.2.3.1 Carletonville Dolomite Grassland

This vegetation unit is encountered in the Central and Western Basins. Within the western basin the impact on the riparian and possibly the terrestrial vegetation will only be the increased water quantity and quality in the Tweelopiespruit down to Hartbeetpoort Dam, no additional infrastructure will be constructed here at this stage. Within the eastern basin the impact on the riparian and possibly the terrestrial vegetation will only be the increased water quantity and quality in the Elsburgspruit and Natalspruit down to Vaal Barrage, no additional infrastructure will be constructed here at this stage.

This vegetation unit mainly occurs in the North-West province but also in Gauteng and marginally into the Free State Province. It is distributed in the region of Potchefstroom, Ventersdorp and Carletonville, extending westwards to the vicinity of Ottoshoop, but also occurring as far east as Centurion and Bapsfontein in Gauteng Province. The altitude ranges from 1 360– 1 620 m.

It occurs on slightly undulating plains dissected by prominent rocky chert ridges. It forms a complex mosaic pattern dominated by many species. Grasses such as *Louditia simplex* (Common Russet Grass), *Hyparrhenia hirta* (Common Thatching Grass), *Brachiaria serrata* (Velvet Signal Grass) and *Heteropogon contortus* (Spear Grass) are prominent while shrubs such as *Euclea undulata* (Common Guarri), *Searsia magalismontana* (Berg Taaibos), *Zanthoxylon capanse* (Small Knobwood) and *Diospyros lycioides* (Bluebush) are scattered in protected places (e.g. among rocks and boulders). The geology of this vegetation unit consists of dolomites and cherts of the Malmani subgroup from the Transvaal super group.

Conservation status is currently considered vulnerable. Only a small extent conserved in statutory (Sterkfontein Caves— part of the Cradle of Humankind World Heritage Site, Oog Van Malmani, Abe Bailey, Boskop Dam, Schoonspruit, Krugersdorp, Olifantsvlei, Groenkloof) and in at least six private conservation areas. Almost a quarter of the type has already been transformed by cultivation, urban sprawl or by mining activity as well as the building of the Boskop and Klerkskraal Dams. Erosion is very low (84%) and low (15%).

6.5.2.3.2 Soweto Highveld Grassland

This vegetation unit is encountered in the Western, Central and Eastern Basins. Within the western basin this vegetation type will be affected by the following infrastructure, the treatment site, the potable water pipeline, the acid mine drainage pipeline, the proposed sludge pipeline and the treated water pipeline. Planning of infrastructure placement will reduce the threat of construction and operation on this vegetation type. The altered water quality and quantity will affect the section of the riparian vegetation of the Tweelopiespruit within this vegetation unit.

Within the eastern basin this vegetation type will be affected by the treated water pipeline and increased water quantity and quality in the Blesbokspruit.

This vegetation unit occurs in Mpumalanga, Gauteng (and to a very small extent also in neighbouring Free State and North-West) Provinces. It lies in a broad band roughly delimited by the N17 road between Ermelo and Johannesburg in the north, Perdekop in the southeast and the Vaal River (border with the Free State) in the south. It extends further westwards along the southern edge of the Johannesburg Dome (including part of Soweto) as far as the vicinity of Randfontein. In southern Gauteng it includes the surrounds of Vanderbijlpark and Vereeniging as well as Sasolburg in the northern Free State. The altitude ranges from 1 420 – 1 760 m.

It occurs on gently to moderately undulating landscape on the Highveld plateau supporting short to medium high, dense, tufted grassland dominated almost entirely by *Themeda triandra* (Rooi grass) and accompanied by a variety of other grasses such as *Elionuris muticus* (Wire grass), *Eragrostis racemosa* (Small heart grass), *Heteropogon contortus* (Spear grass) and *Tristachya leucothrix* (Trident grass).

Only small scattered wetlands, narrow streams and occasional ridges or rocky outcrops interrupt the continuous grassland cover. The geology of the Soweto Integration consists mainly of shale, sandstone or mudstone of the Madzarinwe formation (Karoo supergroup).

Conservation status

Currently considered endangered, only a handful of patches are statutorily conserved (Waldrift, Krugersdorp, Leeuwkuil, Suikerbosrant, and Rolfe's Pan Nature Reserves) or privately conserved (Johanna Jacobs, Tweefontein, Gert Jacobs, Nikolaas and Avalon Nature Reserves, Heidelberg Natural Heritage Site). Almost half of the area already transformed by cultivation, urban sprawl, mining and building of road infrastructure. Some areas have been flooded by dams (Grootdraai, Leeukuil, Trichardtsfontein, Vaal and Willem Brummer dams). Erosion is generally very low (93%).

6.5.2.3.3 Tsakane Clay Grassland

This vegetation unit is encountered in the Western and Central basins. Within the central basin the impact on the riparian and possibly the terrestrial vegetation will only be the increased water quantity and quality in the Elsburgspruit and Natalspruit down to Vaal Barrage, no additional infrastructure will be constructed here at this stage. Within the central basin the impact on the riparian and possibly the terrestrial vegetation will only be the increased water quantity and quality in the Elsburgspruit and Natalspruit down to Vaal Barrage, no additional infrastructure will be constructed here at this stage. Within the eastern basin the impact on the riparian and possibly the terrestrial vegetation will only be the increased water quantity and quality in the Blesbokspruit down to the Vaal Barrage, no additional infrastructure will be constructed here at this stage.

This vegetation unit occurs in Gauteng and Mpumalanga Provinces in patches extending in a narrow band from Soweto to Springs, broadening southwards to Nigel and from there towards to Vereeniging. It also occurs north of the Vaal Dam and between Balfour and Standerton (including Willemsdal). It is situated on an altitude ranging from 1 480 –1 680 m.

It occurs on flat to slightly undulating plains and low hills. The vegetation is short dense grassland which is dominated by common Highveld grasses such as *Themeda triandra* (Red grass), *Heteropogon contortus* (Spear grass), and *Elionuris muticus* (Wire grass) and a number of *Eragrostis* species. The most common forbs belong to the families Asteraceae, Rubiaceae, Malvaceae, Lamiaceae and Fabaceae. Disturbance leads to an increase in abundance of particularly *Hyparrhenia hirta* (Common thatching grass) and *Eragrostis chloromelas* (Curly leaf love grass). The most significant rock is basaltic rock from the Klipriviersberg group (Ventersdorp supergroup).

Conservation status

Currently considered endangered, only 1.5% is conserved in statutory reserves (Suikerbosrant, Olifantsvlei, Klipriviersberg, and Marievale) and a small portion also in private nature reserves (Avalon, Ian P. Coetser, and Andros). More than 60% transformed by cultivation, urbanisation, mining, dam-building and roads. Large portions of Alberton, Springs, Tsakane and parts of Soweto (all south and east of Johannesburg) were built in the area of this vegetation unit. Urbanisation is increasing and further expansion of especially the southern suburbs of Johannesburg and the towns of the East Rand (especially the Brakpan District) will bring further pressure on the remaining vegetation. Erosion is very low (87%) and low (11%) across the entire unit.

6.5.2.3.4 Eastern Temperate Freshwater Wetlands

This azonal vegetation type occurs in all three of the Basins. This vegetation unit occurs in the Northern Cape, Eastern Cape, Free State, North-West, Gauteng, Mpumalanga and KwaZulu-Natal Provinces as well as in neighbouring Lesotho and Swaziland. It is distributed around water bodies with stagnant water (lakes, pans, periodically flooded vleis and edges of calmly flowing rivers) and embedded within the Grassland Biome. The altitude of its distribution area ranges from 750 – 2 000 m.

It occurs on a flat landscape or shallow depressions temporary filled with water and supporting zoned systems of aquatic and hygrophilous vegetation of flooded grasslands and ephemeral herblands.

Conservation status

The type is currently considered vulnerable. About 5% is statutorily conserved in the Blesbokspruit (a Ramsar site), Hogsback, Marievale, Olifantsvlei, Seekoeivlei (a Ramsar site), Wakkerstroom Wetland, Umgeni Vlei, Umvoti Vlei and Pamula Park Nature Reserves. It is also protected in private nature reserves such as the Korsman Bird Sanctuary and Langfontein. Some 15% has been transformed to cultivated land, urban areas or plantations. In places intensive grazing, often combined with wetland drainage, occur. The use of lakes and freshwater pans as drinking pools for cattle or sheep also cause major damage to the wetland vegetation. The Blesbokspruit Ramsar site is a significant focal point for these studies together with the CoH WHS site in the Western Basin.

The conservation status of each vegetation unit is listed in Table 6-9.

Table 6-9: The conservation status of the various vegetation units occurring within the study area (arranged top-down from most to least endangered)

Vegetation unit	Ecosystem Status	Protection level	Transformed	Protected	Target
Soweto Highveld Grassland	Endangered	Hardly protected	± 48%	0%	24%
Tsakane Clay Grassland	Endangered	Hardly protected	± 44%	1%	24%
Carletonville Dolomite Grassland	Vulnerable	Poorly protected	± 24%	2%	24%
Eastern Temperate Freshwater Wetlands	Vulnerable	Poorly protected	± 27%	4%	24%

The aquatic habitat of the Blesbokspruit consists mostly of *Phragmites australis*, bulrushes *Typha latifolia* and sedges which cover 90% of the water surface. These wetlands cover an area approximately 85% of the Marievale Bird Sanctuary. The remaining 15% is grassland which is broadly classified as Bankenveld. A wide variety of flowering plants occur. A few of the more spectacular are the Orange River lily *Crinum bulbispermum*, plough breaker *Erythrina zeyheri* and *Aloe ecklonis* (Haskins 1998).

Fauna in this site of significance for the study includes various rare and Red Data species. Among others Otters, Flamingo and African Grass Owls can be expected to occur. Bittern has not been recorded recently, but, has been known to occur. Factors specific to keystone species in the Ramsar site and specific to Ramsar criteria will be investigated. Of concern here is decrease of open water areas by reed and rush invasion.

6.5.2.4 Terrestrial Fauna

6.5.2.4.1 Animal species of concern

From the desktop work conducted for the project areas the species listed in Table 6-10 were identified as protected according to NEMBA and which may possibly be affected by the project.

Table 6-10: Animal species of concern according to NEMBA.

Common name	Scientific name	NEMBA Status
Rough-haired Golden Mole	*Chrysospalax villosus*	Critically endangered
Blue Crane*	*Anthropoides paradiseus*	Endangered
Cape Vulture	*Gyps coprotheres*	Endangered
Pinkbacked Pelican*	*Pelecanus rufescens*	Endangered
African Clawless Otter*	*Aonyx capensis*	Protected
South African Hedgehog	*Atelerix frontalis*	Protected
African Marsh Harrier*	*Circus ranivorus*	Protected
Black-footed Cat	*Felis nigripes*	Protected
Spotted-necked Otter*	*Lutra maculicollis*	Protected
Giant Bullfrog*	*Pyxicephalus adspersus*	Protected
Black Stork*	*Ciconia nigra*	Vulnerable
Lesser Kestrel	*Falco naumanni*	Vulnerable
Juliana's Golden Mole	*Neamblysomus julianae*	Vulnerable
Martial Eagle	*Polemaetus bellicosus*	Vulnerable
African Grass-Owl*	*Tyto capensis*	Vulnerable

*Depicts species often associated with wetlands and riparian zones

The Blesbokspruit supports a variety of fish, amphibians, reptiles, crustaceans and rodents. Spotted-necked otters (*Lutra maculicollis)*, Water mongoose (*Atilax palidinosus)* and many larger birds depend on these animals for their food. The Reedbuck (*Redunca arundinum)* regarded as uncommon in South Africa, has also been recorded here.

6.5.2.4.2 Reptiles and amphibians

The herpetofauna of wetlands in general tends to be poor due to a paucity of habitat diversity. In addition they are difficult to see in a dense field layer and go into hiding on being disturbed. It is therefore difficult to assess their presence. The frequency of grass fires is detrimental to the existence of reptiles and amphibians not only directly, but also indirectly as they are exposed to predation following the removal of cover, which will result in reduced abundances and possibly in local extinctions of some species.

Table 6-11: Ekurhuleni SoER amphibians.

Common Name	Species	Breeding Requirements
Common River Frog	*Afrana anglolensis*	Rivers and Permanent water, artificail habitats (dams) or pans.
Common Platanna	*Xenopus laevis*	Permanent water, seasonal pans.
Cape River Frog	*Afrana fuscigula*	Permanent water, seasonal pans.
Natal Sand Frog	*Tomopterna natalensis*	Shallow permanent streams or vleis in grassland.
Tremolo Sand Frog	*Tomopterna cryptotis*	Temporary shallow pools/pan or large roadside pools.
Bubbling Kassina	*Kassina senegalensis*	Open vleis, pans, dams in grassland.
Common Caco	*Cacosternum boettgeri*	Marsh, vleis, inundated grassland pools.
Guttural Toad	*Bufo gutturalis*	Open vleis, pans, ponds, dams, slow streams.Dominates artificial habitats. Urban Exploiter.
Raucous Toad	*Bufo rangeri*	Vegetated zones around pans or dams. Extremely rare in the Gauteng Province due topossible hybridisation with Guttural Toads, *Bufo gutturalis*
Red Toad	*Schismaderma carens*	Emerging vegetation in deeper water (.30 cm) often around reed beds (Typha).
Giant Bullfrog	*Pxyicephalus adspersus*	Sedge and grass (hygrophytic) dominated seasonal pans or shallow depressions. May utilise artificial habitats such as dams, ponds. Limited numbers in urban environments. Urban avoider.

Common Name	Species	Breeding Requirements
Striped Stream Frog	*Strongylopus fasciatus*	Vegetated dams, pans and streams. Limited numbers in urban environments. Urban avoider.
Snoring Puddle Frog	*Phrynobatrachus natalensis*	Seasonal pools, pans or around dams. Limited numbers in urban environments. Urban avoider.

In Table 6-11, the amphibians listed in the Ekurhuleni SoER is listed, these species have a high probability of occurring in the study areas, particularly the eastern basin.

1.1.1.1 Avifauna

6.5.2.4.3 Important birding areas

The IBA Programme identifies and works to conserve a network of sites critical for the long-term survival of bird species that:

- Are globally threatened;
- Have a restricted range; and
- Are restricted to specific biomes/vegetation types.

Within the eastern basin the Marievale bird sanctuary is and Important Birding Area with a wetland of Ramsar status and occurs within the eastern basin. It is a permanently inundated reed-dominated (*Typha* and *Phragmites*) wetland. Permanent flooded status is due to artificial inputs of water (e.g. from mines and sewage treatment works). Reedbeds are probably supported by eutrophic status of water.

The Blesbokspruit supports significant numbers of waterfowl, including up to 4000 yellow-billed duck, *Anas erythrorhyncha* and 1000 spur-winged goose *Plectropterus gambensis* in the dry season, when levels are maintained artificially at a high level. The high-productivity water provides food for greater flamingo *Phoenicopterus ruber*, and lesser flamingo *Phoeniconaias minor*, which are South African Red Data Book Species (Haskins 1998). Other notable birds include avocet *Recurvirostra avosetta*, purple heron *Ardea purpe* rata, spoonbill *Platalea alba*, glossy ibis *Plegadis falcinellus* and yellow-billed stork *Mycteria ibis*. African marsh harrier *Circus ranivorus*, which has been displaced from much of the veld, maintains a strong population here. There are at least three heron roosts with a total of over 3 500 birds (Haskins 1998). Increasing urbanization and industrialization in the central Gauteng reduce the number of sites available to the local fauna and flora. The Blesbokspruit supports a variety of fish, amphibians, reptiles, crustaceans and rodents. Spotted-necked otters *Lutra maculicollis*, water mongoose *Atilax palidinosus* and many larger birds depend on these animals for their food (Haskins 1998). The reedbuck *Redunca arundinum* regarded as uncommon in South Africa, has also been recorded here. Avifauna count data is available from biannual CWAC (Coordinated Waterfowl Counts) reports, while species lists are submitted by reserve visitors to BIRP (Birds In Reserves Programme) - both programmes are run by the Avian Demography Unit at the University of Cape Town (Haskins 1998). In Table 6-12 the protected bird species according to the Ekurhuleni Metropolitan Municipality's first year State of the Environment Report (2003), this coincides with the Eastern Basin.

Table 6-12: Ekurhuleni protected bird species. (Avian demography unit)

English name	Genus	Species	Status
African Marsh Harrier	*Circus*	*ranivorus*	VU
Bald Ibis	*Geronticus*	*calvus*	VU
Black Coucal	*Centropus*	*bengalensis*	NT
Black stork	*Ciconia*	*nigra*	NT
Blackwinged Plover	*Vanellus*	*melanopterus*	NT
Blue Crane	*Anthropoides*	*paradiseus*	VU
Blue Korhaan	*Eupodotis*	*caerulescens*	NT
Caspian Tern	*Hydroprogne*	*caspia*	NT
Corncrake	*Crex*	*crex*	VU
Grass Owl	*Tyto*	*capensis*	VU
Greater Flamingo	*Phoenicopterus*	*ruber*	NT
Half-collared Kingfisher	*Alcedo*	*semitorquata*	NT
Lanner Falcon	*Falco*	*biarmicus*	NT
Lesser Flamingo	*Phoeniconaias*	*minor*	NT
Lesser Kestrel	*Falco*	*naumanii*	VU
Melodious Lark	*Mirafra*	*cheniana*	NT
Openbill Stork	*Anastomus*	*lamelligerus*	NT
Painted Snipe	*Rostratula*	*benghalensis*	NT

English name	Genus	Species	Status
Secretarybird	*Sagittarius*	*serpentarius*	NT
Whitebellied Korhaan	*Eupodotis*	*cafra*	VU
Yellowbill Stork	*Mycteria*	*ibis*	NT

6.5.3 Aquatic ecology

The ecological status (integrity) of a river system refers to the overall condition or health of the system. The ecological status of a system refers to an integrated ecological category for the river. This is the totality of the features and characteristics of the river system and the associated riparian areas that rely upon the system's ability to support an appropriate natural flora and fauna and the capacity to provide a variety of goods and services. A suite of ecological indicators are specifically selected for the ability to integrate the impact of multiple disturbances on the state of rivers, these indicators include:

- Instream habitat;
- Water quality;
- Riparian zones;
- Riparian vegetation;
- Fish communities; and
- Macroinvertebrates.

According to the River Health Programme (RHP) (2005) the integrity of the instream habitat is crucial for maintaining biota and a healthy river system. Water quality issues are often a concern and require management responses. It is important to monitor water quality to ensure that the objectives are being adhered to. There are often a number of sources of pollution that are contributing to the reduced levels of water quality for a catchment (RHP, 2005). The riparian zone is considered to be an important ecological link between the river system and the terrestrial component of a catchment (RHP, 2005). Riparian zones may often function as an effective buffer area between the river systems and any potential impacts that might originate from within the catchment. In light of this, the protection of the riparian zones should be a management priority. The ecological classification of a system considers the cause-and-effect relationship for the ecological drivers and responses of a system; this relationship is presented in Table 6-13.

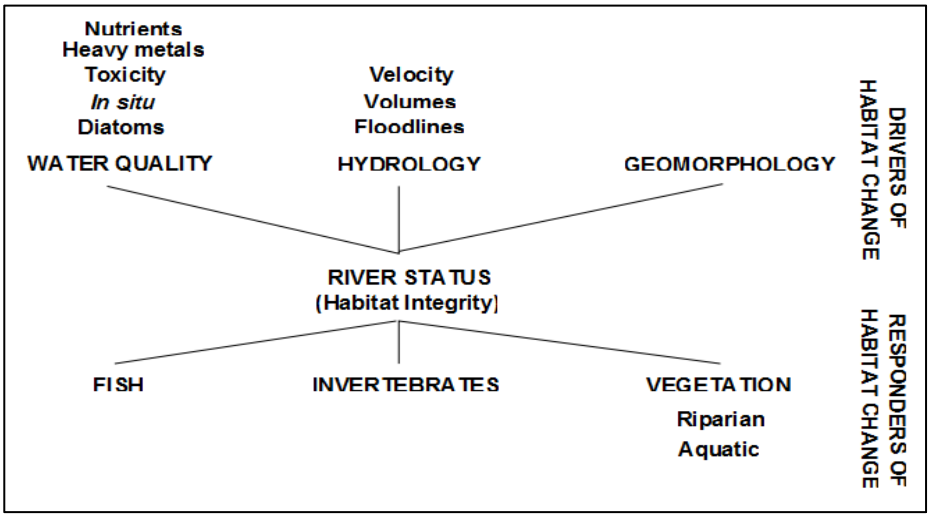

Table 6-13: The cause-and-effect relationship between the drivers and the biological responses.

The Western Basin site is situated within the Crocodile (West) and Marico Water Management Area (WMA 3) and both the Central and Eastern Basin sites are situated within the Upper Vaal Water Management Area (WMA 8). The location of the three basin sites with respect to the Water Management Areas (WMA) and associated water resources is presented in Table 6-14.

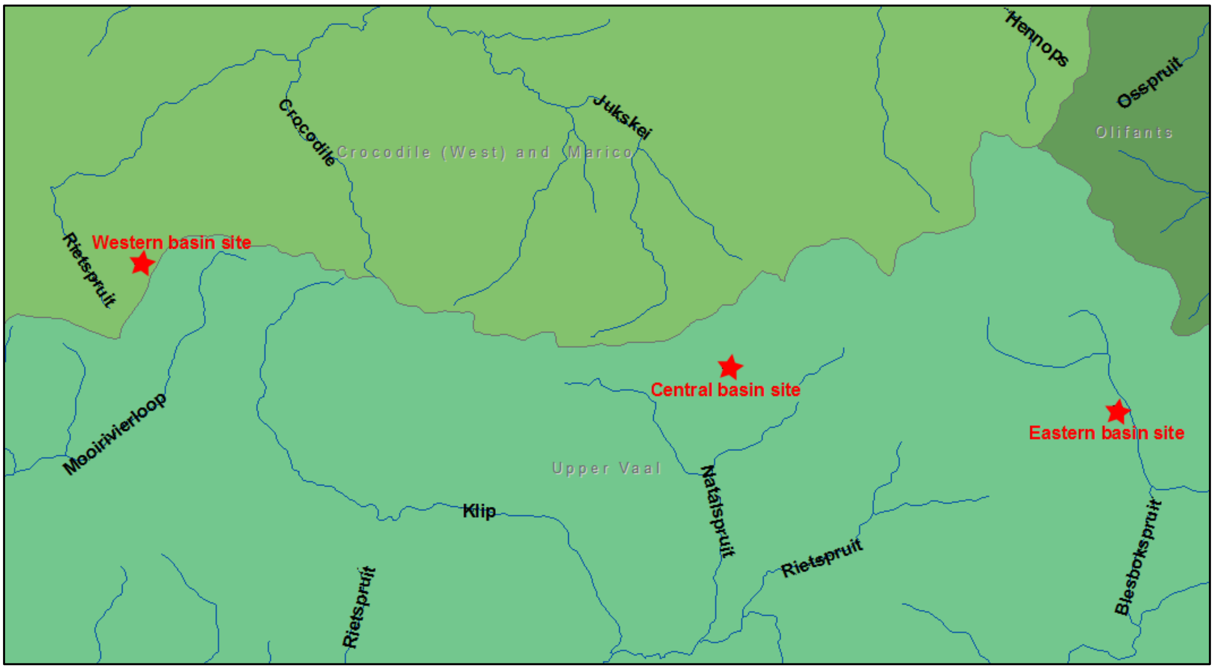

Table 6-14: The project sites located within the respective water management areas, indicating the associated freshwater resources for each catchment.

6.5.3.1 Western Basin

The proposed project site is located within the quaternary catchment A21D. According to Kleynhans (2000) the present ecological management class for this quaternary catchment is a Class B (largely natural). In light of this, the attainable ecological management class for the quaternary catchment remains to be a Class B (Kleynhans, 2000). The water resource which will be directly impacted on as a result of the proposed discharge of treated water into the system is the Tweelopiespruit. The Tweelopiespruit runs alongside the Western Basin site and is a tributary of the Rietspruit which is considered to be a moderately modified (Class C) system. This is an indication that there has been a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged (Kleynhans and Louw, 2007). The Rietspruit flows into the Bloubankspruit which in turn flows into the Crocodile River which is the major river which drains the catchment. The water supply of the Tweelopiesspruit comes from a number of sources, these sources vary from groundwater flow, industrial, sewage and mine works discharge, urban runoff and input from non-perennial tributaries. The location of the project site in relation to the local land cover classes for the WMA as described by the RHP (2005) is presented in Table 6-15.

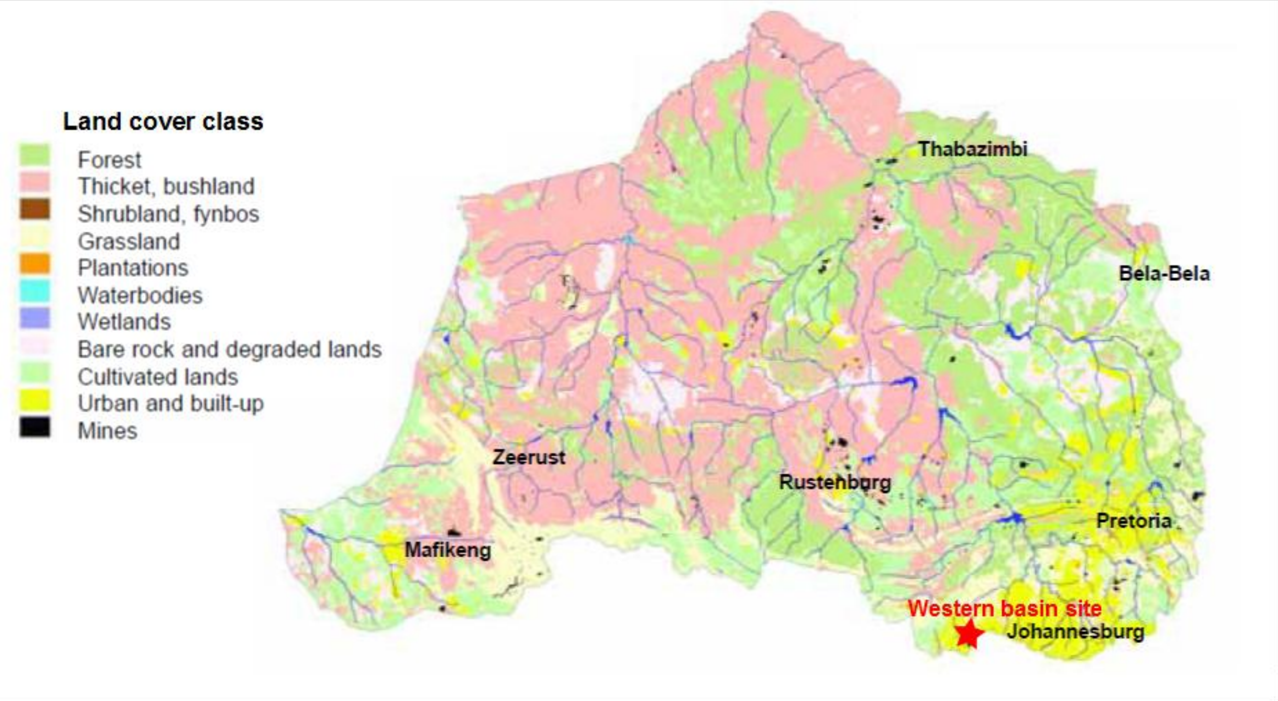

Table 6-15: The land cover classes for the Crocodile (West) and Marico WMA indicating the location of the Western Basin site (RHP, 2005)

The Tweelopiespruit is a first order perennial river which flows in a predominantly northerly direction and this system is considered to have a Class D conservation status indicating that the natural environment is of a largely modified nature. Spontaneous decant was observed in September 2002 in the Western Basin and continues at the current time and flows untreated and uncontrolled, into the Tweelopiespruit. Owing to the development of the associated catchment area and the pressures imposed on the system by the local anthropogenic activities, the status of the system is expected to be in seriously to critically modified state. According to Kleynhans and Louw (2007) this is an indication that a large loss of natural habitat, biota and basic ecosystem functions has occurred. Under the Gauteng conservation plan the river is considered to be irreplaceable, which indicates that no other river systems are available to meet the prescribed ecological targets for the catchment, thus, protection is crucial (Ferrar and Lotter, 2007).

The upper reaches of the Rietspruit is regarded to contain Class C (moderately modified) systems meaning that the biotic systems present are classified as pollution sensitive systems. The aquatic biodiversity of the Tweelopiespruit is considered to be endangered. According to the national FEPA programme, the proposed discharge location for the proposed project area is considered to be situated in an upstream management area (sub-catchment 1185) (WRC, 2011). Upstream management areas are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream river FEPAs and fish support areas. The location of the project area in relation to the described FEPA is presented in Table 6-16. A summary of the respective ecological classes for the local water resources is presented in Table 6-17.

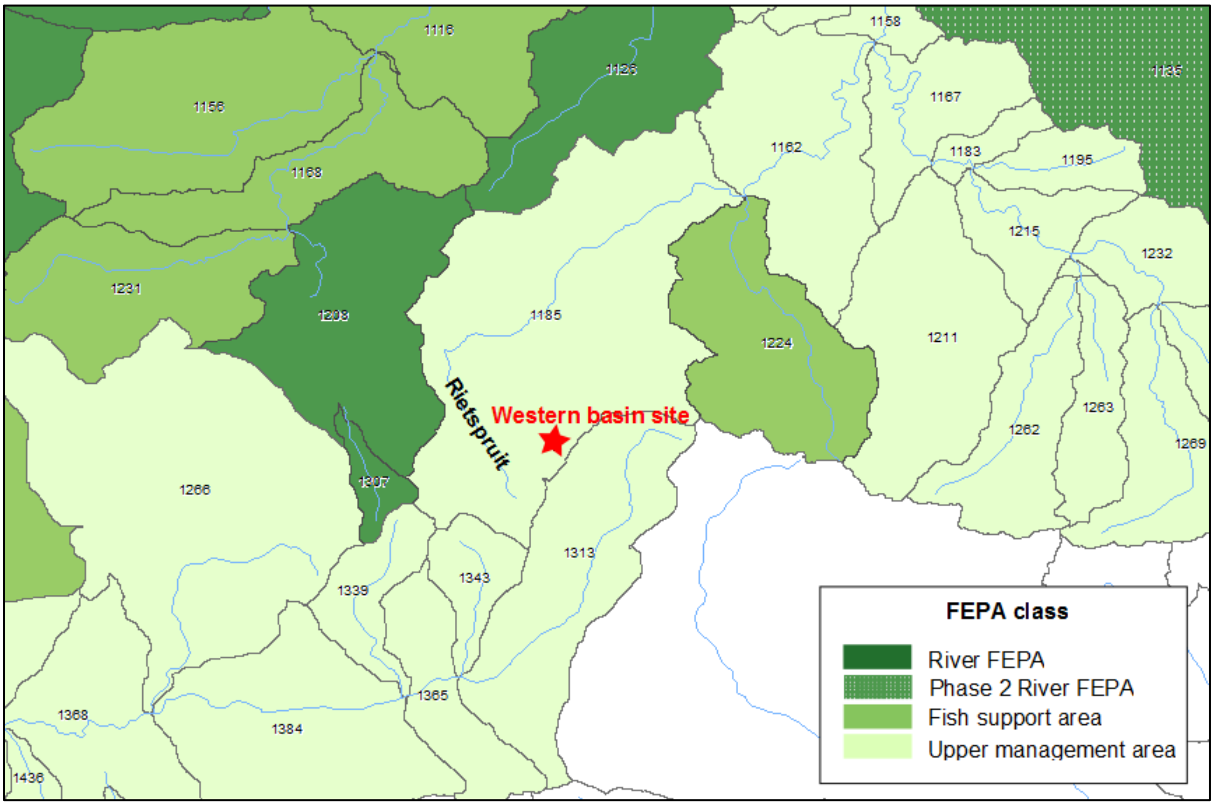

Table 6-16: The location of the project area in relation to the described FEPA

Table 6-17: A summary of the ecological classes for the local water resources

Component	Description
PEMC (Quaternary catchment A21D)	Largely natural (Class B)
AEMC (Quaternary catchment A21D)	Largely natural (Class B)
Rietspruit	Moderately modified (Class C)
Tweelopiesspruit	Largely modified (Class D), most likely a Class E or F
Tweelopiesspruit (Gauteng C-Plan)	Irreplaceable
FEPA	Upstream management area

The water quality of the Tweelopiesspruit has been determined through several studies in recent years. Some of the important water quality measurements were as follows; pH of 3.5, Conductivity of 510 mS/m, TDS of 6 580 (mg/l), Sulphate of 4 010 (mg/l), and iron of 697 (mg/l) (Inter-ministerial Committee, 2010).

6.5.3.2 Central Basin

The quaternary catchment in which the project area is situated is C22B. The present ecological management class for this quaternary catchment is a Class E or F (seriously/critically modified) which is not an acceptable state (Kleynhans, 2000). The described attainable ecological management class for the quaternary catchment is a Class D, which describes a largely modified system. The Elsburgspruit is the system which will be directly impacted on by the proposed discharge of treated water. The Elsburgspruit is a second order perennial tributary of the Natalspruit which in turn flows into the Rietspruit which ultimately flows into the Vaal River.

The Elsburgspruit and the Natalspruit are both in a seriously to critically modified state (Class E or F). This extent of modification is an indication that a critical level has been reached and the systems have been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible (Kleynhans and Louw, 2007). The water supply of the Elsburgspruit comes from a wide variety of sources namely discharges from sewage and mine works, urban runoff and a number of non-perennial tributaries.

The Gauteng conservation plan considers the Elsburgspruit to be irreplaceable, which indicates that no other river systems are available to meet the prescribed ecological targets for the catchment, thus, protection is crucial (Ferrar and Lotter, 2007). The aquatic biodiversity of the Elsburgspruit is viewed as critically endangered. The ecological integrity of the macroinvertebrate and fish populations is considered to be poor (RHP, 2003). According to the national FEPA programme, the proposed discharge location for the proposed project area is considered to be situated in a catchment not considered to be a priority area (WRC, 2011). The location of the project area in relation to the described FEPA is presented in Table 6-18. A summary of the respective ecological classes for the local water resources is presented in Table 6-19.

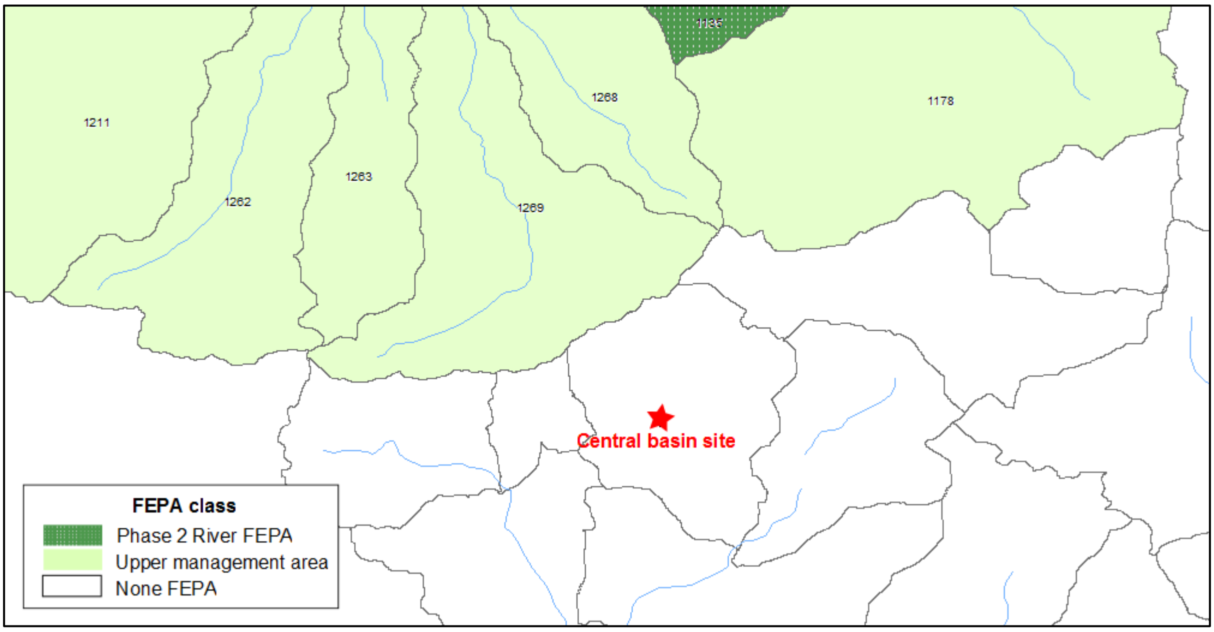

Table 6-18: The location of the project area in relation to the described FEPA

Table 6-19: A summary of the ecological classes for the local water resources

Component	Description
PEMC (Quaternary catchment C22B)	Seriously/critically modified (Class E/F)
AEMC (Quaternary catchment C22B)	Largely modified (Class D)
Elsburgspruit	Seriously/critically modified (Class E/F)
Natalspruit	Seriously/critically modified (Class E/F)
Elsburgspruit (Gauteng C-Plan)	Irreplaceable
FEPA	None

The water quality of the Elsburgspruit has been studied extensively in recent years and has been identified by the DWA as being in a poor condition. The pH of the river has been recorded at as low as 2.8 with a conductivity of 467 mS/m. The TDS has been measured up to 4 936 mg/l with sulphate and iron concentrations recorded at 3 700 mg/l and 112 mg/l respectively (Inter-ministerial Committee, 2010).

6.5.3.3 Eastern Basin

The project area is situated within the quaternary catchment C21E. This catchment area is commonly known as the Blesbokspruit catchment. According to Kleynhans (2000) the present ecological management class for this quaternary catchment is a Class C (moderately modified) which indicates a loss and change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged. The described attainable ecological management class for the quaternary catchment is a Class B, which describes a largely natural system with a few modifications. This indicates that a small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged (Kleynhans and Louw, 2007). The Blesbokspruit is the largest river of this catchment and drains the Blesbokspruit catchment area. The Blesbokspruit is a perennial second order stream and is considered be in a largely modified state (Class D), this indicates that a large loss of natural habitat, biota and basic ecosystem functions has occurred. This system is a tributary of the Suikerbosrant River which finally flows into the Vaal River. A number of wetland areas are also known to occur on the Blesbokspruit. The water supply of the Blesbokspruit comes from a variety of sources, some of which include industrial, residential and mine discharge, several non-perennial streams and tributaries as well as urban runoff and shallow groundwater flow.

The Gauteng conservation plan considers the Blesbokspruit to be irreplaceable, which indicates that no other river systems are available to meet the prescribed ecological targets for the catchment, thus protection is crucial (Ferrar and Lotter, 2007). According to the RHP (2003) the ecological state of the drivers and biological responses associated with the system are in a poor state, and as a result the biodiversity of the system is considered to be critically endangered. According to the national FEPA programme, the proposed discharge location for the proposed project area is considered to be situated in a catchment not considered to be a priority area (WRC, 2011).

The project area is associated with the Blesbokspruit wetland system for which there is currently no formal protection status for this Ramsar site other than that of Marievale Nature Reserve which is a proclaimed nature reserve under the Environmental Management: Protected Area's Act. Act 57 of 2003 (Macfarlane and Muller, 2011). This wetland system, threatened by untreated mine water which is decanting into the system, was designated as a Ramsar Site in October 1986, and listed on the Montreux Record in 1994 as result of the these threats. According to Macfarlane and Muller (2011) the Ramsar requirements and guidelines to manage the Blesbokspruit have not been met. In spite of the system being on the Montreaux record since 1996, very little success has been achieved in addressing the threats and improving management of the system. The location of the project area in relation to the described FEPA wetlands is presented in Table 6-20. A summary of the respective ecological classes for the local water resources is presented in Table 6-21.

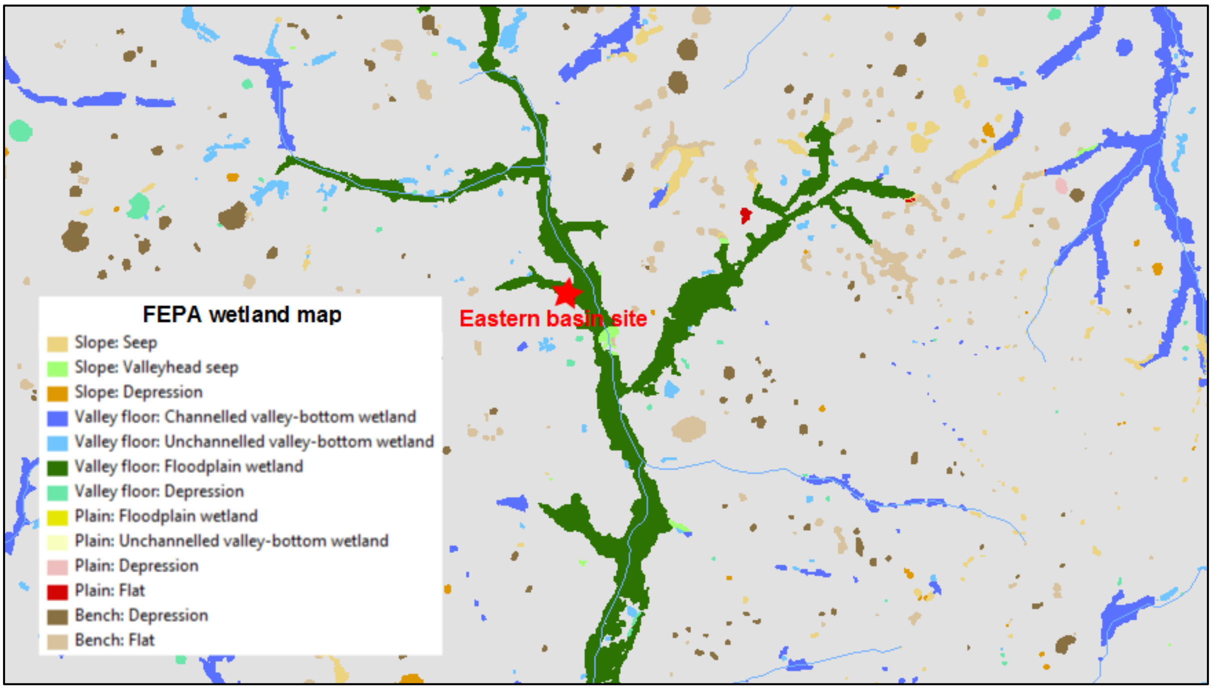

Table 6-20: The location of the project area in relation to the described FEPA wetlands

Table 6-21: A summary of the ecological classes for the local water resources

Component	Description
PEMC (Quaternary catchment C21E)	Moderately modified (Class C)
AEMC (Quaternary catchment C21E)	Largely natural (Class B)
Blesbokspruit	Largely modified (Class D)
Blesbokspruit (Gauteng C-Plan)	Irreplaceable
Blesbokspruit wetland	Ramsar site and Montreux Record
FEPA (wetlands)	Floodplain wetland (Blesbokspruit)

The water quality of the Blesbokspruit has been described to be in a poor condition and this is due to factors such as high concentrations of iron, manganese, sulphate, calcium, magnesium, sodium and chloride. The water quality has been noted to be severely impacted by high TDS concentrations ranging from 2 700 to 3800 mg/L (Schoeman & Steyn, 2000). Uranium has also been noted to be present at concentrations of 0.013 ppm (Winde & Sandham, 2004). According to a study by Randwater in January 2011 the pH has been recorded at 7.45 (de Fontaine, 2011), however this differs from a study carried out by the DWA which recorded the pH of the river to be 6.65.

6.6 Geohydrological environment

A description of the current understanding of the geohydrological or groundwater environment within the Witwatersrand Basin and in particular the Western, Central and Eastern Basins (refer to Plan 18) has been constructed from a literature review of some of the most recent geological, hydrogeological and AMD studies. The Inter-Ministerial Committee Report (December 2010)[3] and the BKS Due Diligence Report (August 2011)[4] provides a detailed collation and assessment of all available AMD and groundwater information within the Witwatersrand area and provides possible solutions and management options to pump, treat and discharge of treated AMD water from the Western, Central and Eastern Basins respectively.

This section merely presents a summary of the geological and hydrogeological characteristics in each of the Basins, as well as proposed treatment and discharge options and associated risks.

6.6.1 The Witwatersrand Basin

The Witwatersrand Basin is a geological formation in the Witwatersrand, South Africa. It holds the world's largest known gold reserves and having produced over 1.5 billion ounces. The basin straddles the North West, Gauteng and the Orange Free State Provinces and is of the same period as the Vredefort impact of 2.023 Ga ago, and the Bushveld Igneous Complex. The name was derived from the white quartzite ridge which strikes parallel to the edge of the basin in which the sediment was deposited.

Nearly half of all the gold ever mined has come from the extensive Witwatersrand Basin that was first found near Johannesburg in 1886. The gold occurs in reefs, or thin bands, that are mined at depths of down to 4 000 m - Mponeng gold mine currently being the world's deepest. Although many of the older mines are now nearly exhausted, the Witwatersrand Basin still produces most of South Africa's gold and much of the total world output. Silver and iridium are recovered as gold-refining by-products and the basin also has coal mines, although they are small players in the basin.

The Witwatersrand Basin (Wits Basin) is a 6 km thick geological sequence of thin sedimentary layers that stretches from just east of Johannesburg in the north, to the southern Free State in the southwest, in the shape of a shallow elliptical dish. It is approximately 300 km long and 160 km wide and outcrops along its northern and north-western edges, tilting down into the earth as it extends further south.

[3] Inter-Ministerial Committee of AMD, December 2010. Mine Water Management in the Witwatersrand Gold Fields with special emphasis on Acid Mine Drainage.

[4] BKS, August 2011. Witwatersrand Gold Fields Acid Mine Drainage. Contract TCTA 08-041. Consulting Services for AMD Phase 1 Option 1. Due Diligence.

It is estimated to have formed between 2.6 and 3.0 billion years ago. Geologists believe that several braided rivers flowed into a huge inland sea that extended across this area at this time. These rivers carried eroded materials down from the surrounding highlands and deposited them in alluvial deltas around the sea, at their respective entry points.

Heavy materials, such as granules, pebbles and heavy minerals were deposited first, building up mineral-rich deltas around the shoreline, while finer sand, clay and silt would have been carried further into the sea. This was happening over millions of years, during which time, various geological changes caused movements that shifted the deposit locations, causing gravel layers to be covered by sand or clay layers, only for those to be covered in turn by later levels of gravel, and again by layers of sand or silt. These deposits piled up over time, layer upon layer, until eventually the lake became silted up.

Several volcanic and metamorphic events are also known to have occurred in the millions of years that followed this, which would have thrust the sequence up in some places, caused it to slip down in others, and also deposited various lava flows or flood basalts, across parts of its surface.

Then approximately two billion years ago, the earth was struck by a massive meteor, which hit a nearby area today known as Vredefort. The impact shattered and lifted an estimated 70 km^3 of rock, and the debris thrown up by this event covered the whole Witwatersrand with a thick blanket of debris.

The Wits Basin was, therefore, preserved as mineralised reefs and hardened under these layers, which provided the heat and pressure necessary to transform the unconsolidated sediments into sedimentary rock.

The Wits Basin gold occurs almost exclusively within quartz pebble conglomerates. While the origins of the sedimentary layers of the Wits Basin are generally agreed upon, there remains much contention as to how the gold itself got there.

Dotted outside the basin are older Archaean granites of between 3 and 3.2 Ga, some of which are exposed while others are covered by the much younger Karroo System. The Witwatersrand System is a sequence of shale, quartzite and conglomerates ranging in age from 2.7 Ga for the Hospital Hill subgroup to 2.4 Ga for the Turffontein subgroup (refer to Plan 18). The Lower Witwatersrand is composed mainly of argillaceous clays and shale with occasional banded ironstone, a tillite and an intercalated lava flow, while the Upper Witwatersrand consists almost entirely of quartzite and conglomerate, with its own volcanic horizon.

There are two leading hypotheses: one called the placer model, which holds that the tiny grains of gold were carried down by the rivers from gold-bearing regions to the north and east of the Witwatersrand Basin, and deposited together with the heavier quartz pebbles in the gravel-rich deltas.

The competing theory is called the hydrothermal model, and this advocates that hot water containing dissolved gold ions, emanating from deep within the earth's crust, was pushed up through the fractures and pores in the sedimentary rock, long after it had been deposited. These then precipitated when they came into contact with the hydrocarbons stored in the rock.

6.6.1.1 Minerals

Over 100 mineral species have been reported from the gold-bearing reefs (www.edu.uni-klu.ac.at/mmessner/sites/rsa/wits/wits.htm). Most of the minerals are esoteric and visible only under the microscope and seldom form larger collector specimens. Zircon, chromite and other heavy minerals occur throughout the Witwatersrand. The most common silicate minerals in the reefs are quartz, muscovite, pyro-phyllite, chloritoid and chlorite. The sulphide minerals are the second most abundant minerals superceded only in volume by quartz. A wide variety of nickel-cobalt-platinum sulpharsenides, as well as copper sulpho-salts and antimony-bearing minerals are present. Included in this group are species such as cobalt-rich arsenopyrite, gersdorrite and cobaltite, and the platinum group minerals geversite, sperrylite, braggite and cooperite. Pyrite is present in a variety of habits and forms. The main uranium-bearing minerals are uraninite and brannerite with minor amounts of coffinite and uanothorite. Uranium (and gold) tends to be enriched when found in combination with carbon. In some places a reef – the Carbon Leader – is developed and mined as the gold content is exceptionally high.

The strata in the gold mines have been subject to tremendous pressures and deformation resulting in the fracturing of the rocks along fault zones. Furthermore the Witwatersrand strata were introduced by younger igneous rocks which are often associated with the faults. These two features result in favourable conditions for the percolation and migration of fluids with often large quantities of dissolved silica in them. It is in these fluids that the quartz crystallised.

6.6.2 Geohydrology of the Western Basin

The Witwatersrand Gold Fields in the Western Basin comprises the following three gold reefs:

- Black Reef;
- Kimberley Reef; and
- Main Reef.

These reefs sub-outcrop on the north-western side of the Gold Fields between Randfontein and Roodepoort, but the sub-outcrop is isolated from the rest of the Gold Fields by the Witpoortjie and the Roodepoort Faults (Plan 19).

Mining in the weathered zone from surface started along the reef outcrops in the Randfontein / Krugersdorp area and, when the reefs became too deep for this type of access underground mining commenced by means of constructed shafts. When most of the reefs had been removed, underground voids were left that stretch from Randfontein and Krugersdorp to the Witpoortjie Fault. The Western Basin thus stretches from Randfontein to

Roodepoort and is separated from the Far Western Basin and the Central Basin by the Witpoortjie and Roodepoort Faults, respectively, as shown in Plan 18.

The Western Basin incorporates the old gold mining operations centred around Randfontein Estates, West Rand Consolidated, Luipaardsvlei and East Champ d'Or Mines. Mining operations ceased in around 1998 and the old mine workings progressively filled with water. Water started decanting from the Black Reef Incline (BRI) shaft in 2002. High rainfall over the past three years has caused decant from Winze 17 and 18 as well (BKS, Report No. J01599/05, August 2011).

The current mining operations on the Western Basin are exclusively associated with the re-mining and recovering of old sand and TSFs. The two largest re-mining operations are:

- Rand Uranium, which is re-mining the old Dump 20, a source of gold bearing sand. This material is railed from the Western Basin to the Cooke Gold Plant outside the Western Basin; and
- Mintails, which is re-mining several gold-bearing TSF's using its Mogale Gold Plant. The residual tailings are deposited in the Wes Wits Pit.

Rand Uranium also plans to extend its current gold mining operations, to re-commission the Millsite Tailings Dam and to use several of the opencast pits associated with the reef sub-outcrops as tailings deposition sites.

Currently AMD is decanting naturally with the majority flowing untreated down the Tweelopiespruit and into the Bloubankspruit that flows past the Sterkfontein caves and across the Zwartkrans dolomitic compartment. Most of the Tweelopiespruit water is recharging back into the groundwater environment (Zwartkrans compartment) at a point just north of the Krugersdorp Nature Reserve. This point coincides or is very close to the position where the Rietfontein fault crosses the Tweelopiespruit. The Rietfontein fault extends from the Percy Steward sewage treatment plant in a northewesterly direction towards Magaliesburg. Surface and groundwater monitoring could not confirm whether the extent of the contaminated water plume extends much further downstream along the Tweelopiespruit from this sink. The option, whether this water is recharging another dolomitic sub-compartment and whether this possible sub-compartment will eventually spill over and decant at another locality towards the northwest has to be investigated.

Large scale irrigation activities can be observed from the Steenkoppie compartment (west of Zwartkrans compartment). It is unlikely that these compartments are connected as a series of parallel dykes (Tarlton West and Tarlton East dykes) separate them. Even if they were connected, the threat of AMD contaminating the Steenkoppie compartment via the Zwartkrans compartment would be low as the natural and regional groundwater flow direction is from the west to the east – Steenkoppie to Zwartkrans compartments.

Discharged water from the Percy Steward and the Randfontein sewage treatment plants are also flowing across the Zwartkrans dolomitic compartment and down the Tweelopiespruit.

6.6.2.1 Groundwater recharge and flow

In the Western Basin, a number of distinct surface sources of recharge to the Basin contribute to the water make (BKS, Report No. J01599/05, August 2011) and includes:

- Seepage from:
  - overlying and adjacent groundwater aquifers;
  - surface mine pits which are, in some cases, connected to the underground mine workings; and
  - surface mine tailings and sand dumps;
- Ingress from surface streams and rivers crossing the old mine workings; and
- Losses from potable water, sewage and storm water reticulation systems.

The water recharge is seasonal and responds to rainfall and runoff events.

A number of studies have been completed over the last decade to gain insight into the mine water recharge and flow rates from the Western Basin. The following reports have been reviewed in selecting suitable mine flows:

- A report by RM Krantz (1996), based on anecdotal information, reported that the average flow rates from Randfontein Estates Limited was 27 Ml/day, as recorded from 1995, while the mine was still operational;
- The original groundwater balance for the Western Basin, prepared by Krantz (1996), indicated that the dry season recharge was 21 Ml/day and the wet season recharge was 27 Ml/day; and
- The Council for Geoscience (CGS), in preparing a Regional Closure Strategy for the Western Basin, proposed a recharge figure of at least 23 Ml/day. The CGS report also indicated a potential variation in mine water recharge of 18-40 Ml/day.

More recently, the mining companies have been recording the mine water decant flows from the Western Basin.

The mine water recharge and corresponding decant flows are seasonal with high recharge occurring mainly in summer. The result of the mine workings being filled is that no storage or buffer capacity is left in the old mine workings. As recharge occurs, mine water flows from the decant points.

The Western Utilities Corporation (WUC) report estimates the long-term sustainable water supply from the Western Basin to be 16 Ml/day. This is a conservative estimate and it is anticipated that the recharge to the mine workings will decrease progressively as open pits are filled in and rehabilitated.

6.6.2.2 Water quality

The water in the Western Basin represents mature AMD, which corresponds to a situation when the pyrite oxidation products accumulated in the mine workings are progressively flushed. It may take some time to observe a significant improvement in water quality. The current best estimate of AMD quality is shown in Table 6-22. *(*BKS, Report No. J01599/05, August 2011- *Annexure A. Basis of Engineering Design).*

Table 6-22: Western Basin Water Quality (BKS, August 2011)

Parameter	Unit	Black Reef Incline Concentration		IMC Report Concentrations
		Median	95^{th} percentile	
Total Dissolved Solids (TDS)	mg/L	6 733	7 174	6 580
Electrical Conductivity (EC)	mg/L	506	548	510
Calcium (Ca)	mg/L	400	461	
Magnesium (Mg)	mg/L	218	345	
Sodium (Na)	mg/L	103	139	
Sulphate (SO_4)	mg/L	4 083	4 556	4 010
Chloride (Cl)	mg/L	46	65	
pH		3.6	3.4 – 4.0	3.5
Acidity ($CaCO_3$)*	mg/L	1,740	2,560	
Iron (Fe)	mg/L	725	933	697
Aluminium (Al)	mg/L	29	54	
Manganese (Mg)	mg/L	148	312	
Uranium (U)	mg/L	0.1	0.2	

6.6.3 Geohydrology of the Central Basin

Mining in the Central Basin of the Witwatersrand Gold Fields started 125 years ago after the discovery of gold in 1886. The Central Basin mines were dewatered to the deepest mining depths until 1974, when most of the mines in the Central Basin were no longer operational (Scott, 1995). After 1974, the water level in some of the mines was allowed to rise, while some mine dewatering continued, but by 1995 the main dewatering took place on the extreme western and eastern edges of the basin, at DRD and ERPM respectively.

In 2008, the last mine dewatering in the Central Basin was stopped at ERPM. The water level in the basin has been rising since then. The locality and extent of the Central Basin is shown in Plan 20.

6.6.3.1 Groundwater level rise and recharge

The ECL was confirmed for the Central Basin at 150 m below the ERPM Cinderella East shaft (a probable decant shaft) with collar level of 1 617 mamsl, or ECL level of 1 467 mamsl (186.2 m below SWV).

The water level in the Central Basin (measured on 13 May 2011 by DRD Gold) was 1 199 mamsl, about 454 m below surface measured at SWV Shaft, or about 268 m below the ECL. The water level measured at Gold Reef City Shaft No.14 on the same day had an identical reading, which indicates that the water level in at least part of the Central Basin is rising at the same rate over the entire basin.

Details of the model and methods used to the Central Basin water level rise and decant can be found in Water Balance and Levels (BKS Report number J01599/06).

Based on the results from the Central Basin simulations, it is expected that the water will reach ECL in August 2012 (average rainfall) while, if allowed to happen, decant would occur around March 2013[5]. These dates are based on annual average rainfall data. A number of rainfall / recharge scenarios were also evaluated and the predicted dates for reaching ECL are as follows:

- Above average rainfall: June 2012;
- Average rainfall: August 2012; or
- Below average rainfall: December 2012.

The interconnectivity (i.e. locations and levels of cross cuts and holings) of the Central Basin is reasonably well understood. However, the potential flow rate of water between compartments in the basin and the water level profile along the length of the basin under various dewatering pump rates is not fully understood (BKS, Report No. J01599/05, August 2011). DWA developed a water level monitoring system, which can be used to optimise the required pump level to account for any level changes along the basin.

Although the interconnectivity of the Central Basin is understood and, until recently (2008), it was possible to drain the Central Basin from the ERPM SWV shaft, the current condition of the cross-cuts and holings is unknown. Scott (1995) states that mining on the Witwatersrand created sheet-like openings that are continuous laterally and with depth, to maximum mined

[5] More recent data suggests that the ECL will be reached in August 2013 and decant would follow in December 2014.

depths of 3 500 m. In cases where the stope is a discontinuous sheet, it is joined by access haulages and drives.

The geological structure is that of a basin, with the rim more steeply dipping than the basin bottom, which may be horizontal. In the Central Basin, dips of 60-70 degrees can be found and the average dip is about 45 degrees. Where the mine openings dip steeply, the forces are such that, even when unsupported, they remain open.

The collapse or closure of cross-cuts and holings is possible and this could impact the possibility of dewatering the basin from a single point.

Furthermore, draining the basin to allow mining will remove the water that is providing some of the support, and it is expected that there may be an initial increase in seismic activity, which could have an impact on basin connectivity.

The potential decant point has been debated and there is no consensus on the point of decant. As expected, if the connectivity between the various sub-basins in the Central Basin is good (high transmissivity), decant will occur at the lowest point connected to the Central Basin void. The lowest known direct points of connection are the mineshafts on the eastern side of the basin (ERPM shafts), with Cinderella West and East being the lowest points (collar heights of 1 614 m and 1 617 mamsl, respectively). There are possibly other points where decant can occur first, i.e. through reef outcrop, geological faults and old abandoned mine pits or shafts. By the time decant occurs, Level 5 of Gold Reef City Shaft will be flooded.

The Johannesburg CBD has many tall buildings with deep foundations, some of which have piled foundations. Various reports in the media indicated that these deep foundations might be at risk from the rising AMD. Johannesburg CBD ground levels are generally above 1,750 m to the north and west, dropping to about 1 700 m in the southeast. Therefore, there is approximately an 80 m buffer at the expected decant level (1 617 m) and a 230 m buffer at the ECL. The water level is rising at the same rate across the Central Basin (between ERPM and Crown Mines), so it is expected that decant will occur without any impact on the buildings in the CBD (BKS, Report No. J01599/05, August 2011).

6.6.3.2 Water quality

The Central Basin has not been active for the past 2 to 3 years in terms of active dewatering. Although historical mine water quality records, for when active mining was still taking place, are available from mining companies, the current geochemical conditions associated with flooding of the old mine workings would be materially different from the past situation of active mining and associated preferential flow paths. The flooding of the mine workings has probably mobilised accumulated pyrite oxidation products, which would result in the rapid deterioration of accumulated mine water. It is therefore sensible to allow for more impacted mine water in the planning and design of the mine water abstraction and treatment infrastructure. *(BKS Report No. J01599/01, included as Annexure A Basis of Engineering Design)*

Table 6-23 summarises the current best estimate of the past and anticipated mine water quality, based on the work documented in the Western Utility Corporation report and the IMC report.

Table 6-23: Central Basin Water Quality (BKS, August 2011)

Parameter	Unit	Black Reef Incline Concentration		IMC Report Concentrations
		Median	95th percentile	
Total Dissolved Solids (TDS)	mg/L	5 950	7 ,700	4 936
Electrical Conductivity (EC)	mg/L	560	730	467
Calcium (Ca)	mg/L	500	580	
Magnesium (Mg)	mg/L	330	380	
Sodium (Na)	mg/L	105	150	
Sulphate (SO_4)	mg/L	4 000	5 200	3 700
Chloride (Cl)	mg/L	180	270	
pH		2.6	3.5	2.8
Acidity ($CaCO_3$)*	mg/L	1 690	2 425	
Iron (Fe)	mg/L	750	1 000	112
Aluminium (Al)	mg/L	30	50	
Manganese (Mg)	mg/L	30	60	

*Calculated

6.6.4 Geohydrology of the Eastern Basin

Mining in the Eastern Basin of the Witwatersrand Gold Fields started in about 1888 at the Nigel Mines and in about 1892 at Van Ryn Estates, slightly later than the mines on the Central Rand. The Eastern Basin encloses a surface area of 768 km^2 and includes Brakpan, Springs and Nigel (Scott 1995) as shown in Plan 21.

Water ingress into the Eastern Basin has been a problem since the earliest days of mining (Scott 1995). The Eastern Rand mines were dewatered to about 220 mamsl (to accommodate deep level mining) until the early 1990s, when the basin dewatering taking place from the Sallies No. 1 shaft was stopped. Dewatering continued at Grootvlei No. 3 shaft, maintaining a level of about 780 mamsl, until the middle of 2010, when all pumping in the basin stopped. The water level in the basin has been rising ever since.

6.6.4.1 Expected rate of rise and decant

The ECL was confirmed for the Eastern Basin as 1 280 mamsl. The reasons for selecting this level as the ECL are documented in Environmental Critical Levels (BKS, Report No. J01599/03, August 2011).

The water level in the Eastern Basin was not a concern until 2010, when pumping stopped at Grootvlei No. 3 shaft. The water level measurement at Grootvlei No. 3 shaft on 21 April 2011 was at 917 mamsl (or 653 m below surface).

Based on geo-hydrological modelling done for the Eastern Basin (Water Balance and Levels (BKS, Report No. J01599/06, August 2011) it is expected that the ECL water level will be reached in April 2015, while decant (if allowed to happen) would occur in around September 2015. These projected dates are based on annual average rainfall. If above-average rainfall occurs, the ECL will be reached earlier, possibly as early as in December 2014[6].

The interconnectivity of the Eastern Basin is reasonably well understood, i.e. levels of cross-cuts and holings; however, the potential flow rate of water between compartments within the basin and the water level profile across the basin under various pump rates is not fully understood. DWA developed a water level monitoring system, which can be used to optimise the required pump level to account for any level changes along the basin.

Although the interconnectivity of the Eastern Basin is understood and until 2010 it was possible to drain the Eastern Basin from the Grootvlei shaft, the current condition of the cross-cuts and holings is unknown.

Scott (1995) provides a description of the interconnectivity:

"The mines in the northern part of the area are interconnected and there is no restriction to water movement between individual mines. In the southern region Sub Nigel and Nigel Mines are continuously connected. The mines in the central part of the Eastern Basin are connected only in certain places and water flowing through this region will have to find and follow preferred pathways. There is no connection between Marivale Mine and the Nigel Mine, the connection to the lowest point at Nigel Mine is via Vogelstruisbult to Sub Nigel at 61 level.

Thus it would appear that the water from Springs Mines, East Daggafontein and Marivale would first have to flow into Vogelstruisbult where a connection exists (61 level 8 haulage) to Sub Nigel Mine. Water will rise in the Sub Nigel Mine and then into the Nigel Mine to emanate at surface. Thus the limiting factor is the connection between Vogelstruisbult and

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[6] The latest available information indicates that the ECL will be breached in May 2014 and that decant would occur 28 months later in August 2016.

Sub Nigel Mine. If flow is restricted at this level then the water will rise at Marivale No. 4 or No. 7 shafts instead of in the Sub Nigel and Nigel Mines."

Scott (1995) states that the rocks making up the Witwatersrand Supergroup in this area form an asymmetrical, south-west-plunging syncline. Dips on the northern limb are about 45 degrees, while those on the southern limb are about 25 degrees. As discussed for the Central Basin, where the mine openings dip steeply, the forces are such that even when unsupported, they remain open. This could make the Eastern Basin more sensitive to collapse, especially in the southern limb where the dip is only around 25 degrees.

Therefore, it can be stated that the risk of collapse or closure of cross-cuts and holings is higher in the Eastern Basin than in the Central Basin. This could impact the possibility of dewatering the basin from a single point. Filling of the cross-cuts and holings with water will, however, provide support and reduce the risk of collapse. Contingency plans have been considered to address the potential risk of connectivity problems (formation of sub-basins not connected to the Eastern Basin).

It is expected that decant from the Eastern Basin will occur at Sub-Nigel Shaft 3 (collar level 1 549 mamsl), which is the lowest known connection point to the Eastern Basin void; however, according to Scott (1995), should the flow between Vogelstruisbult and Sub-Nigel be restricted, the water will probably decant at the Marivale 4 or 7 shafts instead of in the Sub-Nigel and Nigel Mines.

Furthermore, Gold One, which owns the Sub-Nigel mines, has indicated an interest in possibly plugging some of the mines to enable the continuation of mining. This could isolate these mines from the Eastern Basin, but may also have the unexpected consequence of creating a sub-eastern basin in the Nigel Mines.

The surface elevation of the Nigel CBD are approximately at decant level to about 10 m above decant level. Therefore, at the level of decant, buildings with deep foundations may be impacted if there is connectivity to the Eastern Basin void (either direct connection or through geological faults).

6.6.4.2 Water quality

The expected water quality is defined in Basis of Engineering Design (BKS, Report No. J01599/01, August 2011).

The Eastern Basin has always had better water quality than the Western and Central Basins, which seems to be due to the lower concentration of pyrites in the rock below the water level and the recharge through the alkaline dolomites. This, however, is expected to change as the water rises into the Kimberley Reef, which typically has higher pyrite content than the Main Reef (Scott 1995). The Kimberley Reef was mined to a lesser extent than the Main Reef, so it provides a much smaller contact surface. Also, the rapid filling of the Eastern Basin does not provide contact time between water, oxygen and pyrite, which should have a positive impact on the AMD water quality.

Mine water quality in the Eastern Basin is of a relatively good quality for a number of geohydrological reasons, such as recharge of the mine workings with relatively good quality dolomitic water. However, as the basin is flooded, and due to associated mobilisation of accumulated pyrite oxidation products, the water quality will deteriorate in time if not addressed.

The historical water quality data, measured at Grootvlei Mine and the anticipated Eastern Basin, flooded basin water quality is shown in Table 6-24, based on the work documented in the Western Utility Corporation report.

Table 6-24: Eastern Basin Water Quality (BKS, August 2011)

Parameter	Unit	Black Reef Incline Concentration		IMC Report Concentrations
		Median	95^{th} percentile	
Total Dissolved Solids (TDS)	mg/L	2 880	4 405	5 500
Electrical Conductivity (EC)	mg/L	295	360	450
Calcium (Ca)	mg/L	395	440	550
Magnesium (Mg)	mg/L	160	185	230
Sodium (Na)	mg/L	220	260	325
Potasium (K)	mg/L	5		15
Sulphate (SO_4)	mg/L	2 400	2 620	3 275
Chloride (Cl)	mg/L	16	205	260
pH		6.5	5.9 (5^{th} perc.)	5.0
Alkalinity ($CaCO_3$)	mg/L	230	40 (5^{th} perc.)	0
Acidity ($CaCO_3$)*	mg/L	220	460	750
Iron (Fe)	mg/L	120	247	370
Aluminium (Al)	mg/L	0.1	0.3	1
Manganese (Mg)	mg/L	3.5	6.0	10.0
Nickel (Ni)	mg/L	0.3	0.4	1

*calculated

6.7 Surface water environment

AMD has a profound impact on the water quality of receiving streams. Close to the point of discharge untreated decant water results in unstable chemical conditions when it enters the surface water environment. The underground mining environment engenders a decant water that is characterised by extreme acidity, oxygen deficiency, high salinity and elevated temperature. The acidity mobilises metals, dominated by iron and a whole range of other metals including radionuclides. Oxygen starvation results in most of the iron being in the ferrous form, which though stable in the mining void, is unstable in the surface water environment. The high salinity often results in unacceptably high the concentrations of individual ions.

When first discharged the extreme acidity, high metal concentrations and high salinity renders the AMD highly detrimental to all categories of water use. This water is deceptively clear and sterilises life forms in the aquatic environment in the immediate vicinity of the point of discharge. Contact with surface material and the atmosphere soon neutralises the acidity while at the same time the ferrous iron fully oxidises to the characteristically red ferric form, with unsightly deposition of sediment that stifles benthic biota. Neutralisation of the acidity greatly reduces the solubility of metals, which also form part of the sediment. This also helps reduce the salinity of the stable water that finally emerges further down the stream. While highly detrimental to the local riverine environment, the water that emerges further downstream is no longer acidic, is free from excessive metals (and hence radioactivity), no longer has a propensity to deposit sediment and has a somewhat lower salinity. The warm temperature also reverts back to normal ambient conditions. There is a risk that some of the metals deposited further upstream may be remobilised and transported downstream during floods. However, solubility will remain much lower than in the original AMD and hence the metals (and any associated radionuclides) will tend to be confined to the sediment. While salinity is reduced, it remains high and acts in a conservative manner, adversely affecting the salinity throughout the downstream river system. Virtually the only mitigation of the salinity is through dilution by incremental catchment runoff and removal of water by abstraction and seepage loss.

Water treatment has a similar effect, except that the oxidation and neutralisation all takes place in a controlled environment in the treatment plant. Hence acidic and deposition damage of the upper reaches of the stream is obviated and the sediment is safely removed before the final product is discharged to stream. The product water salinity is likely to be similar to that of the decant water after natural oxidation and neutralisation has taken place, (Although some differences might result from contact with dolomitic rock downstream of the Western Basin which would favour more representation of the magnesium cation after natural decant. Moreover the solubility of naturally occurring sodium sulphate, magnesium sulphate and potassium sulphate salts also differ from that of calcium, thereby changing the deposition of the insoluble portion of each salt.)

Increased salinity holds substantial economic consequences for urban, industrial, mining and irrigation, aquaculture and (to a lesser extent) livestock users. Elevated salinity can also adversely affect the aquatic environment. Since the mine water in these Basins is predominately calcium-sulphate, it tends not to affect soil drainage even at high salinity levels. (In fact gypsum is often applied to irrigated lands to prevent the clogging of soil pores.) However, high chloride and magnesium concentrations can blemish fruit and damage leaves and high salinity as such reduces crop yields and can force switches to less valuable crop types.

It is anticipated that over time the salinity of the decant water will gradually improve. For example, since 1995 the salinity of the discharge from Grootvlei Gold Mine has improved from about 3 600 mg/l to 2 000 mg/l. This is attributable to a combination of a reduced rate at which sulphates are formed by oxidation of pyrites, gradual replacement of the saline water stored in the mine void with rainfall ingress and short-circuiting, with reduced movement of water through the deeper parts of the mining void. The reduced sulphate formation rate is caused by oxygen starvation in the inundated portion of the void, with new oxygen input limited by the amount dissolved in the rainfall ingress water, whereas before during operation the mining void was exposed to the atmosphere.

Two gold mining basins on the Witwatersrand are faced imminent decant, while in one decant has already commenced.

6.7.1 Western Basin

Plan 22 shows the Western Basin decant point and the downstream affected rivers of the Crocodile West Catchment. The decant water discharges to the Tweelopiespruit, which flows towards the Rietspruit, Bloubankspruit and the Crocodile River. Increased salt loads are anticipated in these river reaches, in Hartbeespoort Dam and beyond.

The Western basin is distinct from the other two basins in that the mining void has already filled, with uncontrolled decant to the Tweelopiespruit since 2002. As expected the upper reaches of this stream are sterile, characterised by very low pH, low oxygen concentration, high salinity and elevated temperature. Contact with catchment runoff, stream bed and the atmosphere results in neutralisation, oxygenation of iron and associated deposition of metals (including uranium), ferric iron and excess calcium sulphate, all of which suffocates benthic organisms in a blanket of sludge. Further downstream the water is again stable and clear and the temperature has reverted to normal, however, high salt concentrations persist.

However up to 2010 there was no evidence of the effect of the mining decant on water salinity at DWA weir A2H019 on the Bloubankspruit. This was surprising since for a normal river reach the low flow salinities at this point were expected to have more than trebled and the flow-weighted salt load entering Hartbeespoort Dam via the Crocodile River ay A2H012 should have increased by 35%.

There was no evidence of the expected large increase in salinity for the first nine years because decant water enters an underlying dolomitic compartment where the groundwater level was drawn down by natural processes and irrigation abstractions. As a result, for the first nine years there was little spillage of the polluted water from the compartment back to the surface runoff, with the result that no change was evident at DWA station A2H049 on the Bloubankspruit. However, the flood of 16/17 December 2010 caused a steep rise in salt concentration (see Table 6-25) that persisted for 3 months. It is surmised that natural and abstraction losses from the dolomitic compartment detained most of the AMD input from 2002 to 2010, during which time TDS concentrations in the compartment gradually increased. This gradual rise was not apparent at A2H049 until after the compartment filled and the flood caused substantial spillage of the contaminated water leading to a sharp rise in TDS concentration at A2H049. It has been calculated that once long-term equilibrium conditions are reached, when the outgoing salt load approximates the increased incoming load, that the AMD could increase the salt load entering Hartbeespoort Dam via the Crocodile River by about a third, despite inputs from the biggest WWTW in Southern Africa plus several other large WWTWs. The recent peak at A2H049 does not yet reflect this condition, but does provide clues as to how long it would take to reach this state.

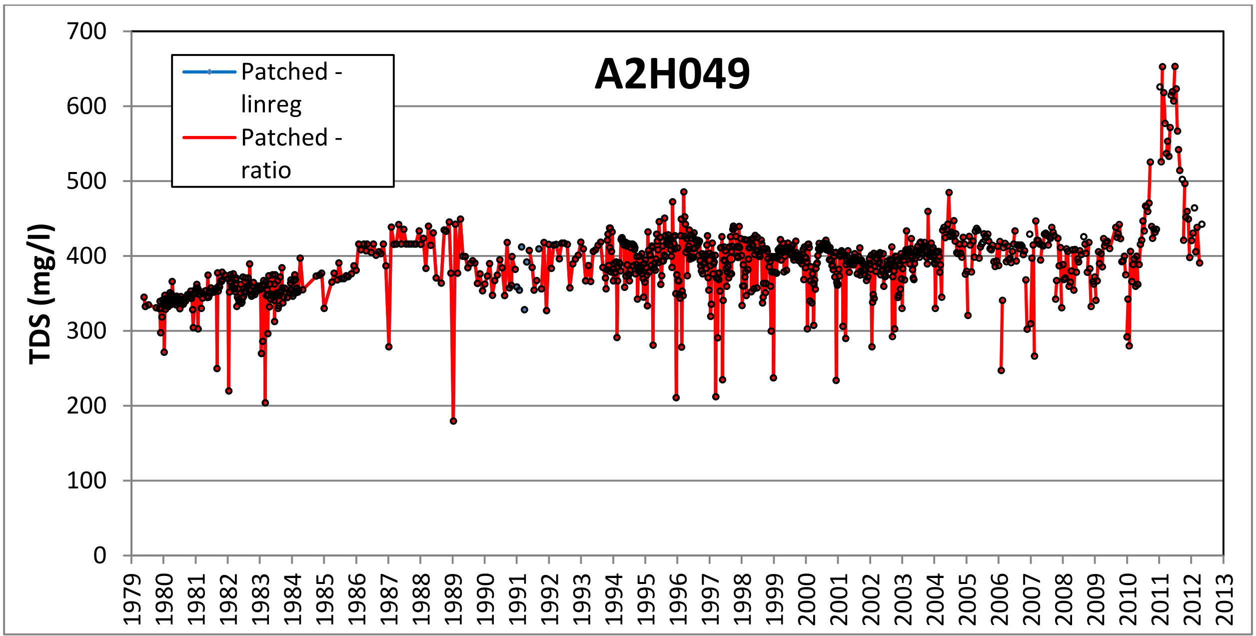

Table 6-25: Long-term TDS trend at weir A2H049

This significant change highlights the need to include the dolomitic storage and groundwater abstraction and loss effect. It also points to the magnitude of the change in salinity and the resulting impact on users.

A number of impacts relate not only to the salinity as such, but to the concentrations of individual components of the TDS. Sulphate is of particular concern in this regard.

This increase in salinity would affect crop yields in the extensive irrigated areas downstream of Hartbeespoort Dam and substantially increase salinization costs to urban and industrial consumers. This is especially important since DWA is investigating the potential development of a large regional water purification works at Hartbeespoort Dam to supply water to the Pretoria West area. Irrigation downstream of Roodekoppies Dam would also be affected. A scheme to transfer water from the lower Crocodile River to the Moloko River catchment to supply salt-sensitive Eskom power stations is also being developed.

Hence it may be prudent to include the Crocodile River at Roodekoppies Dam (A2R015) and two points in the Lower Crocodile River to facilitate estimation of the economic effects on irrigation users and the water transfer to the strategic industries in the Waterberg area.

6.7.2 Central Basin

Plan 23 shows the proposed Central Basin treated water discharge point and the downstream affected Vaal River system. At present there is no discharge from the Central Basin. After implementation of the short term intervention, treated decant water would discharge to the Elsburgspruit, which flows into the Natalspruit, Rietspruit, Klip River and Vaal River. Increased salt loads are anticipated in these river reaches, affecting salt concentrations in Bloemhof Dam and beyond to Douglas Weir.

Treated water discharge will lack most of the adverse effects currently present in the upper reaches of the Tweelopiespruit since the governing processes will take place in the HDS plant rather than the river. However, the temperature will still be elevated (although it would have cooled a bit in the plant) and the salinity will still be high.

The substantially increased salt load would enter Vaal Barrage thereby increasing the amount of water required from Vaal Dam to dilute the outflow from Vaal Barrage to protect the water quality supplied by downstream water boards and municipalities. Spillage of water from Bloemhof dam during drought sequences would also reduce system yield and trigger the need to augment raw water importation, resulting in substantial economic impact.

During drought periods when it is necessary to suspend the Vaal Barrage dilution option and revert to the less water demanding Rand Water blending option, TDS levels in the water supplied by Rand and throughout the downstream Vaal River system will increase leading to increased salinisation costs to urban and industrial consumers. The large Vaalharts irrigation scheme and riparian irrigators would also be affected, resulting in further economic impact.

The no-go option would result in uncontrolled decant, leading to contamination of the upper reaches of the Elsburgspruit in a manner similar to similar to those currently pertaining to the Tweelopiespruit. I.e. initial sterilisation, followed by a stretch of the river being discoloured and the bed blanketed with a sludge consisting of metal hydrides and gypsum, followed by clear saline water.

The effects of salinity on the downstream Vaal River system would be similar to those for the treatment option, although the salinity may differ somewhat.

6.7.3 Eastern Basin

At present there is no such discharge, following the closure of Aurora mine.

The proposed Eastern Basin treated water discharge would be to the Blesbokspruit near the head of the Blesbokspruit wetland. The downstream system that would be affected by radically increased salinity levels includes the Blesbokspruit, Suikerbosrant and Vaal River and downstream dams. This option would have similar effects on salinity levels in the downstream river system.

The no-go option for the Eastern Basin would result in decant emerging far to the south at Nigel, downstream of the Blesbokspruit wetland. The water quality changes in the Blesbokspruit would be similar to those described for the Elsburgspruit for the Central Basin. The larger dilution afforded by upstream sewage discharges may to some extend attenuate these negative impacts.

The economic impacts on downstream urban and industrial and irrigation users and of reduced Vaal system yield would be similar (but of different magnitude) to those described for the Central Basin.

7 PUBLIC PARTICIPATION PROCESS

Public participation is an essential and legislative requirement for environmental authorisation. The principles that demand communication with society at large are best embodied in the principles of Chapter 1 of NEMA. In addition, Section 24 (5), Regulation 54 – 57 of GNR 543 under NEMA, guides the public participation process that is required for an EIA process.

The public participation process for the Witwatersrand Gold Fields AMD project has been designed to satisfy the requirements laid down in the above legislation and its guidelines. This section of the Final Scoping Report highlights the key elements of the public participation process to date.

It should be noted that there are a number of other channels of communication being utilised in addition to the processes occurring officially as part of this AMD EIA process by the DWA and TCTA to communicate aspects of this project. As they are not under the control of Digby Wells we cannot list them comprehensively or ensure what form or frequency they may take.

The objectives of public participation during the EIA process are to provide sufficient and accessible information to I&APs in an objective manner so as to:

During the Scoping Phase:

- Assist I&APs with identifying issues of concern, and providing suggestions for enhanced benefits and alternatives;
- Contribute their local knowledge and experience; and
- Verify that their issues have been considered and to help define the scope of the technical studies to be undertaken during the Impact Assessment.

***During Impact Assessment*:**

- Verify that I&AP issues have been considered either by the EIA Specialist Studies; and
- Comment on the findings of the EIA, including the measures that have been proposed to enhance positive impacts and reduce or avoid negative impacts.

The key objective of public participation is to ensure transparency throughout the process and to promote informed decision making.

7.1 Approach

The public participation process is being undertaken to encourage active engagement from stakeholders so that suggestions and comments can be incorporated into the project design and that concerns and conflicts can be openly addressed in an on-going manner. Through the Public Participation Process (PPP) adequate and timely information is provided to all

I&APs to ensure that they are given sufficient opportunity to voice their opinions, concerns and issues.

7.2 Identification of Interested and Affected Parties

The identification of I&APs is on-going and is refined throughout the process. As the on-the-ground understanding of affected stakeholders improves through interaction with various stakeholders in the area, the database is updated. The identification of key stakeholders and community representatives for this project is important and their contributions are valued.

Identification of I&APs took place through responses to newspaper advertisements and site notices and through referrals from I&APs who have registered for the project. I&APs' details are captured on Maximiser version 12, an electronic database management software programme. According to the NEMA EIA Regulations under Section 24(5) of NEMA, a register of I&APs (Regulation 55 of GNR 543) must be kept by the public participation practitioner. Such a register has been compiled and is being kept updated with the details of involved I&APs throughout the process (See Appendix F). As of the 17 August 2012 there were 1105 I&APs registered on the database.

7.3 EIA application form and landowner notifications

The EIA application form (Appendix G) for the proposed project was submitted to the DEA on 12 December 2011. Subsequent to the submission of the application form a letter notifying potentially directly affected land owners and occupiers were sent via registered mail. Proof of the notification letters were attached to the application form which was submitted to the DEA. A copy of the letter is attached as part of Appendix H.

7.4 Authority consultation

Authority meetings are being held every two months with the following authorities:

- Department of Environmental Affairs;
- Department of Water Affairs;
- National Nuclear Regulator;
- Ekurhuleni Metropolitan Municipality; and
- Mogale City Local Municipality.

Thus far four authorities meetings have taken place on the 14 February 2012, 17 April 2012 19 June 2012 and 21 August 2012. All meetings are held at DWA's Gauteng Regional Offices in Pretoria. The purpose of these bi-monthly meetings is to inform authorities of the progress of the project, key milestones and to receive their inputs and advice on the EIA process.

7.5 Announcement of opportunity to become involved

The opportunity to participate in the AMD EIA project was announced in December 2011 and again in February 2012. The documentation that has been developed for the PPP is described below and attached as Appendix I.

7.5.1 Background Information Document

A Background Information Document (BID) and I&AP registration forms were developed and distributed to various stakeholders and I&APs from 7 December 2011 onwards. The BIDs included information regarding the following:

- Description of the project;
- Legal framework to be adhered to;
- Locality and extent of the proposed project;
- Specialist studies to be undertaken;
- Approach to the EIA;
- PPP that will be followed; and
- Invitation to public open days.

The I&AP registration form was included as part of the BID and provided I&APs with an opportunity to raise issues of concern and comments regarding the proposed project, and to register as I&APs for the EIA process.

7.5.1.1 Newspaper adverts

A number of newspaper adverts have been placed during the scoping phase of the project. The dates and newspapers advertised in are detailed in **Error! Reference source not ound.** and **Error! Reference source not found.**.

Table 7-1: Newspaper adverts placed in December 2011

Newspaper	Date of Publication
Sowetan	12 December 2011
The Springs Advertiser	14 December 2011
The Springs African Reporter	16 December 2011
Randfontein/ Westonaria Herald	16 December 2011

Table 7-2: Newspaper adverts placed in February 2012

Newspaper	Date of Publication

Newspaper	Date of Publication
Beeld	14 February 2012
The Star	14 February 2012
Sowetan	14 February 2012
Randfontein Herald	21 February 2012
Springs Advertiser	22 February 2012
African Reporter	24 February 2012

During June and July 2012 adverts were placed informing stakeholders of the availability of the Draft Scoping Report for review, as shown in **Error! Reference source not found.**.

Table 7-3: Newspaper and media adverts placed in June / July 2012 advertising the availability of the Draft Scoping Report

Newspaper	Publication date
AgriSA	June /July Edition
Farmers Weekly	27 July 2012
Heidelberg / Nigel Herald	27 June 2012
Landbou Weekbald	13 July 2012
Nufarmer & African Entrepreneur	August Edition
Sasolberg Ster	03 July 2012
Triangle Courier	24 July 2012
Randfontein Herald	15 June 2012
The Springs Advertiser	13 June 2012
The Springs African Reporter	15 June 2012
Beeld	14 June 2012
The Star	14 June 2012
Sowetan	14 June 2012

In compliance with the NEMA regulations, newspaper advertisements were published in English, Afrikaans, IsiZulu and Setswana. Proof of placement of the newspaper advertisements are provided in Appendix J.

7.5.1.2 Site notices

Site notices were positioned at prominent localities within the project area during December 2011 and February 2012. These site notices were placed at conspicuous public places to invite stakeholder participation. Please refer to Appendix K for proof of site notices placed in the project area.

7.6 Consultation and written notification

7.6.1 Telephonic consultation

Throughout the scoping process, telephonic consultation with identified and registered I&APs took place to:

- Obtain and verify contact details;
- Inform I&APs of the proposed project;
- Inform I&APs of, and invite them to the public open days; and
- Gather any issues, comments and suggestions regarding the project.

7.6.2 Written notifications

Email: This method of distributing information was used mainly for I&APs who have access to email. BIDs including I&AP registration forms were emailed to stakeholders.

Hand-Delivery: BIDs were hand delivered to potentially directly affected and surrounding farmers and land occupiers and documents were also distributed during the one-on-one consultation meetings.

7.6.3 Public information sharing meetings and one-on-one sessions

Various public information sharing meetings as well as one-on-one discussions were held with I&APs to present them with information regarding the proposed project. These meetings served a purpose of providing I&APs with a platform to raise their issues and comments regarding the proposed project. Comments raised from these meetings have been recorded and incorporated in the Comments and Response Report (CRR), attached as Appendix L. The meetings held during the scoping phase are detailed below.

7.6.3.1 EIA interest group meetings

The first EIA interest group meeting was held on Wednesday, 22 February 2012 at the Turbine Hall in Newtown, Johannesburg. The aim of this meeting was to engage with the key stakeholders and to provide them with an opportunity to raise comments, questions and suggestions regarding the proposed immediate and short term interventions for the treatment of AMD. Issues raised at the meeting are included in the CRR. A second EIA interest group meeting was held on Wednesday 11 July 2012 at the Sunnyside Hotel

Parktown. The purpose of this second meeting was to present the Draft Scoping Report to key stakeholders and to receive their comments on the report.

7.6.3.2 Public open days

Three public open days were held in the Western, Central and Eastern Basins during the announcement of the project. The purpose of these open days was to present project information to the broader public and to allow I&APs to engage with the project team members (**Error! Reference source not found.**). Issues raised at the open days are ncluded in the CRR. Please refer to **Error! Reference source not found.** for details of the Public Open Days.

Table 7-4: Details of the public open days

Location	Venue	Date	Time
Western Basin	Randfontein Golf Club	25 February 2012	09:00-16:00
Central Basin	Germiston Golf Club	03 March 2012	09:00-16:00
Eastern Basin	Springs Country Club	10 March 2012	09:00-16:00

Figure 7-1: Discussions with I&APs during a public open day

7.6.3.3 One-on-one consultations and notifications

One-on-one consultations were conducted with the relevant local authorities, directly affected and surrounding land owners in the Western, Central and Eastern basins. Not every landowner along the affected rivers was consulted.

The legislative requirement for notification of I&APs was followed as per GN R 543 (of 18 June 2010) Section 54 which states:

The person conducting must give notice to all potential interested and affected parties of the application which is subjected to public participation by—

(b) giving written notice to-

(i) the owner or person in control of that land if the applicant is not the owner or person in control of the land;

(ii) the occupiers of the site where the activity is or is to be undertaken or to any alternative site where the activity is to be undertaken;

(iii) owners and occupiers of land adjacent to the site where the activity is or is to be undertaken or to any alternative site where the activity is to be undertaken;

(iv) the municipal councillor of the ward in which the site or alternative site is situated and any organisation of ratepayers that represent the community in the area;

(v) the municipality which has jurisdiction in the area;

(vi) any organ of state having jurisdiction in respect of any aspect of the activity; and

(vii) any other party as required by the competent authority;

(c) placing an advertisement in-

(i) one local newspaper; or

(ii) any official Gazette that is published specifically for the purpose of providing public notice of applications or other submissions made in terms of these Regulations;

(d) placing an advertisement in at least one provincial newspaper or national newspaper, if the activity has or may have an impact that extends beyond the boundaries of the metropolitan or local municipality in which it is or will be undertaken.

The regulations clearly state that owners and occupiers of land adjacent to the site where the activity is to be undertaken or to any alternative site should be given written notice. For this EIA, owners and occupiers of land adjacent to the water treatment facilities have been given written notification. It is our opinion that written notice does not have to be given to every person adjacent to an impacted river / spruit as this is not the project site, and this could potentially include millions of people. However, notification was also provided to municipalities and ward councillors organised agriculture, irrigation boards, NGOs and ratepayers associations as appropriate, along the rivers to the confluence with the Vaal River in the Central and Eastern Basins and as far as the Hatebeespoort Dam in the Western Basin these included the following stakeholders as presented in **Error! Reference ource not found.**.

Table 7-5: Notified I&APs along the impacted rivers

Basin	Stakeholders to be consulted
Western Basin	• Municipal Managers and relevant Ward Councillors of: ○ Mogale City LM (W30 and W27)

Basin	Stakeholders to be consulted
	○ Madibeng LM (W29) ○ City of Tshwane (W48) ○ Randfontein (W9) ○ GTDMA41 • Organised agriculture (TLU, NAFU, Agri-SA) • Irrigation boards • Specific NGOs/activist groups (e.g. HWAG) • Rate payers associations
Central Basin	• Municipal Managers and relevant Ward Councillors of: ○ Ekurhuleni (W32, W42, W39, W40, W44, W47, W60, W63, W62, W101, W61) ○ Midvaal LM (W5, W4, W14, W3, W13, W2) ○ Emfuleni LM (W15, W19, W4, W5, W7) ○ Metsimaholo LM (W14, W19) • Organised agriculture (TLU, NAFU, Agri-SA) • Irrigation boards • Specific NGOs/activist groups (e.g. Save the Vaal) • Rate payers associations
Eastern Basin	• Municipal Managers and relevant Ward Councillors of: ○ Ekurhuleni (W67, W75, W76, W88) ○ Lesedi LM (W10, W9, W8, W11, W2, W5, W6, W1) ○ Midvaal LM (W1) • Organised agriculture (TLU, NAFU, Agri-SA) • Irrigation boards • Specific NGOs/activist groups (e.g. Save the Vaal) • Rate payers associations

The one-on-ones with landowners were focused around the discharge points as it is felt that this is where the greatest impact from the project will be felt as the discharge will be most undiluted around these points.

Refer to **Error! Reference source not found.** for one-on-one meetings held to date.

Table 7-6: One-on-one consultations held to date

I&AP Name	Organisation/ Farm	Date
Rex Zorab	Rand Uranium	02 November 2011
Ms Mariette Liefferink; Dr Koos Pretorius; Ms Simone Liefferink	Federation for a Sustainable Environment	23 January 2012
Mr Jaco Schoeman Mr Henry Gouws	DRD Gold	10 March 2012
Mr Albie van Rooy	Sterkfontein 173 portion 16	15 March 2012
Mr Piet Schutte	Sterkfontein Portion 8	15 March 2012
Mr Carel Botes	Sterkfontein 173, portion 7	15 March 2012
Mr Chris Grobler	Fauna Visions, Sterkfontein 173	15 March 2012
Mr I Jardin	Sterkfontein 173	15 March 2012
Mr and Mrs Delport	Plot 88, Oak Tree	15 March 2012
Mr Jannie Rykaard	Krugersdorp Game Reserve	15 March 2012
Mr Paul Hoogendyk	Sterkfontein Country Estates	15 March 2012
Ms Elize Strydom	Sterkfontein 173, portion 6	15 March 2012
Mr Reg Tarr	Sterkfontein 173, portion 3	15 March 2012
Mr Louis Trichardt	Sterkfontein Country Estates	15 March 2012
Mr Garfield Krige	Sterkfontein Country Estates	15 March 2012
Cllr Andy Mathibe; Peter Tladi; Cllr Paul Molapo; Cllr Dikgang Sithole; Cllr. Zakhele Dlamini; and	Mogale City Local Municipality	20 March 2012

I&AP Name	Organisation/ Farm	Date
Ms Samukelisiwe Mdlalose		
Cllr Hillary Coke; Cllr Tania Campbell; Cllr Charlie Crawford; Cllr Mbuyiseli Xakambana; Cllr Primrose Sibidli	Ekurhuleni Metropolitan Municipality (Germiston)	30 March 2012
Mr Anthony Kesten; Ms Miemie von Maltitz; Ms Annamarie Maurizi; Ms Sonia Mothodini; Ms Elsabeth van der Merwe ; Mr Nico van den Berg; Mr Smuts Marais; Mr Callie Smit; Mr Barend Deming; Ms Ilse Kleinhans; Ms Lilian Kwakwa; Ms Maphuthi Moabelo Ms Cecilia Rakgoale; Ms Mthokozisi Nkosi; Ms Gavin Ramaboea	Ekurhuleni Metropolitan Municipality (Germiston)	03 April 2012
Mr Matthew Havenga ; Mr Phil De Jager; Mr Bill Ross Adams; Ms Judy Fuchs; Mr Rob Taylor; Mr Piet van der Walt; Mr Sam Khoza; Ms Ria Jacobs; Ms Sibongile Sithole;	Eastern Basin Surrounding landowners.	. 20 April 2012

I&AP Name	Organisation/ Farm	Date
Mr John Duncan; Mr Thabo Sibuyi; Mr Gunte Jacques Kommer; Ms D Klonaris		

7.7 Draft Scoping Report

The purpose of the PPP in the Scoping phase is to enable I&APs to verify that their contributions have been captured, understood and correctly interpreted, and to raise further issues. At the end of scoping phase, the issues identified by the I&APs and by the environmental technical specialists, have been used to define the Terms of Reference for the Specialist Studies that will be conducted during the Impact Assessment Phase of the EIA. The Draft Scoping Report, including the CRR was distributed for comment as follows:

- It was placed at public venues within the vicinity of the project area. (These are listed in **Error! Reference source not found.** below);
- The Draft Scoping Report was presented in the following forums:
  - A second EIA interest group meeting was held with key stakeholders;
  - Open days / public meetings were held in each of the basins;
  - Meetings with disadvantaged communities in the central basin took place; and
  - Landowners and farm workers meetings were held in the Western and Eastern basins.
- CDs were mailed to key stakeholders; and
- CDs were mailed to I&APs who request the report.

The Draft Scoping Report was made available for review from the 28 June 2012 to 7 August 2012.

Table 7-7: Locations where the Draft Scoping Report was made available for review

Location	Contact	Contact Tel	Address
Westrand District Municipality	Ms Stoffberg	011 411 5250	Cnr Sixth and Park Streets, Randfontein
Mogale City Local Municipality	Ms Cindy Ramalatswa	011 951 2101	Cnr Commissioner and Market

Location	Contact	Contact Tel	Address
			Street, Krugersdorp
Johannesburg City Library	Ms Essie Shaphi	011 870 1239	Cnr. Market Street & Fraser Street
Nigel Library	Mr Ignatius Lechelele	011 999 9216	86 Hendrik Verwoerd Street, Nigel
Brakpan Library	Ms Orna Kemp	011 999 7748	Cnr Park and Kingsway Street
Krugersdorp Library	Ms Monica Fourie	011 951 2441	Cnr Von Brandis and Market streets, Krugersdorp
Randfontein Library	Ms Marjorie Sabir	(011) 411 0076)	Corner Pollock & Sutherland, Randfontein
Germiston Library;	Ms Edith Kruger	(011) 871-7867	Corner Queen and Cross Street, Germiston
Springs Library	Ms Tebogo Kekana	(011) 999 8801	55 5th Avenue, Springs
Magaliesburg Library	Ms Lorato Senwedi	(011) 951 1761	Ubuntu Arts & Crafts Centre, Koster Road Magaliesburg
Haartebeespoort Library	Ms Nola van Heerdern	(012) 253 2075	Marais Street Schoemansville, Haartebeespoort
Vosloorus Library	Ms O Kidson	(011)999 5937	MC Botha Avenue, Voosloorus
Thokoza Library	Ms Qoshiwe Matcheke	(011) 999 2499	7603 Moepshe Street, Alberton

Location	Contact	Contact Tel	Address
Vanderbijlpark Library	Ms Elmarie Slater	(016) 950 5252	Klasie Havenga Street, Vanderbijl Park
Vereeniging Library	Ms Maria Mtimkulu	(016) 450 3164	Cnr Leslie & Market Street

The Draft Scoping Report was also made available on the Digby Wells Environmental website; www.digbywells.com and on the AMD website; www.amdshort.co.za.

7.7.1 Notification of the availability of the Draft Scoping Report

A letter notifying stakeholders that the Draft Scoping Report was available for public review was sent to the stakeholder database on 18 June 2012. The letter invited participants to obtain a copy of the Draft Scoping Report at any of the public places or to request a CD copy of the document. The letter also invited participants to attend any of the public meetings listed in **Error! Reference source not found.** and **Error! Reference source not found.** ich were held to present the contents of the Draft Scoping Report. In addition to the letter which was sent to all stakeholders, the availability of the Draft Scoping Report and the planned public meetings were advertised in the newspapers listed in **Error! Reference ource not found.**.

Table 7-8: Public meetings to review the Draft Scoping Report

Meeting	Date and time	Venue
Public meeting (and open house) Western Basin	17 July 2012 at 14:00	Randfontein Golf Club
Public meeting (and open house) Central Basin	18 July 2012 at 14:00	Germiston Golf Club
Public meeting (and open house) Eastern Basin	19 July 2012 at 14:00	Stable Inn Conference Centre

In addition to the above mentioned public meetings, the following meetings were held with focus groups to review the Draft Scoping Report:

Table 7-9: Focus Group meetings to review the Draft Scoping Report

Meeting	Date and time	Venue
EIA Interest Group meeting	11 July 2012 at 14:00	Sunnyside Hotel Parktown

1st Central Basin community meeting (Extension 9)	21 July 2012 at 09:00	Ward 35, Ext 9 Taxi Rank
Western Basin community meeting with farmers and farm workers	24 July 2012 at 14:00	Makiti Conference Venue
Eastern Basin community meeting with landowners and workers	25 July 2012 at 14:00	Stable Inn Conference Venue
2nd Central Basin community meeting (Cyril Ramaphosa)	28 July 2012 at 09:00	Ward 42 Cyril Ramaphosa Taxi Rank

Table 7-10: Newspaper adverts for the notification of the review of the Draft Scoping Report

Newspaper	Date of Publication
Randfontein Herald	12 June 2012
Springs Advertiser	13 June 2012
The African Reporter	13 June 2012
Sowetan	14 June 2012
The Star	14 June 2012
Beeld	14 June 2012
Agri SA (Die Boer/ The Farmer)	July Edition
Farmers Weekly	27 July 2012
Heidelberg / Nigel Herald	27 June 2012
Landbou Weekblad	13 July 2012
Nufarmer & African Entrepreneur	August Edition
Sasolberg Ster	3 July 2012
Triangle Courier	24 July 2012

7.8 Comments and response report and acknowledgements

All the issues raised up until the 17 August 2012 are captured in the CRR and is appended to this Final Scoping Report as Appendix L. The attached comments and response report has been categorised into the flowing key issues and responses and are summarised in **Error! Reference source not found.**.

Table 7-11: Key issues and responses

Issue	Response
The importance for the EIA to investigate alternatives particularly the no-go alternative.	The EIA will investigate alternatives including the no-go option.
How and who will finance the interventions?	The immediate and short term interventions capital investment for the infrastructure will be funded by the government. The intention of government is that capital cost incurred will eventually be recovered from the water users and the mines. One of the objectives of the long term solution is to determine a model for financial recovery.
The impact of the project on downstream users.	This will be investigated in the EIA
Water quality issues particularly the release of water containing high TDS.	This will be investigated in the EIA
Water quantity issues relating to the release of additional water down the streams.	The impact of the additional water being released will be investigated in the EIA.
The reasons why the project is not going the full treatment route including desalinisation.	The reason that desalination is not implemented within the current phase, is to allow the correct selection of operation and treatment to be determined by the Long Term solution feasibility study.
The projects impact on the Vaal River and the potential of the project causing the Vaal river going into deficit.	Aurecon is looking at the long term solution which will also address the issue of the Vaal River going into deficit.
The impact of the project on groundwater.	The EIA will investigate the full extent of impact on the groundwater system.
The impact of the project on the ecology of the rivers.	The EIA will investigate the impact on the ecology and will suggest mitigation measure
The impact of the project on human and animal health.	This will be investigated in the EIA.
Public Participation ensuring that the project is made known to as many people as possible	The EIA has been well advertised as per the public participation process. Meetings targeting

Issue	Response
particularly the disadvantaged.	the disadvantaged have been undertaken.
Due legal processes to be followed particularly around the use of section 24G.	TCTA has taken a decision to proceed with the EIA process and then apply for a section 24 G if required. If TCTA wait for authorisations, the ECL will be breached and decant in the Central and Eastern Basin will occur.
Treatment technologies and particularly alternative technologies.	Alternatives will be investigated as part of the EIA.
Sludge disposal and the potential impacts on groundwater.	Sludge disposal options will be investigated in the EIA.

Detailed issues and responses can be found in the CRR Appendix L.

The CRR will be updated throughout the EIA process to include additional I&AP contributions that may be received as the study proceeds, and as the findings of the EIA become available.

7.9 Final Scoping Report

The Final Scoping Report has been updated with additional issues raised by I&APs and contains new information. The Final Scoping Report will be distributed to the DEA, key I&APs, and to those individuals who specifically request a copy.

The Final Scoping Report, including the CRR was distributed for comment as follows:

- Made available electronically on the Digby Wells Website and on the AMD Short Website; and
- CDs will be mailed to I&APs who request the report.

No EIA interest group meeting will be held and no public meetings will be held. When the Draft EIA is ready for public review another round of meetings will be held.

8 POTENTIAL IMPACT IDENTIFICATION

The proposed AMD Project may have potential impacts on the social and biophysical environments. These impacts may result from the construction and operational activities planned for the proposed project, with reference to the NEMA listed activities discussed in Chapter 2 (Table 2-2).

Table 8-1 was compiled to summarise the environmental aspects and potential impacts associated with the AMD Project.

Table 8-1: Potential impacts associated with the construction and operation of the proposed AMD Project

Environmental Aspect	Potential Impact
Surface Water Quality	
Discharge of treated water into the streams.	Deteriorating water quality in streams affecting beneficial water uses. Elevated sulphate levels affecting human and animal health. Elevated temperature, conductivity, pH, O_2 content, sulphates, heavy metals and micro-organisms in impacted streams. Many of these variables hold direct health and other water use impacts, as well as promoting damaging sludge blankets.
Discharge of water containing high TDS into the receiving rivers.	Reduction yield of Vaal River system due to elevated salt load entering Vaal Barrage.
Water Quantity	
Increase in water volumes in the receiving catchments due to the treated water discharge.	Flooding – inundation of riparian property (incl. informal areas, footpaths, access roads, etc.). This will support the social impact studies. Flooding – impact on low level bridges, structures, etc., affecting level of service and stability of the structures. This will support the social impact and economic impact studies. Flooding – impact on stability of farm dams, and especially spillways due to the potential of persistent spilling due to higher base flows. This will support the social impact and economic impact studies.

Environmental Aspect	Potential Impact
	Channel stability, especially in upper reaches of study area. Higher base flows may change the dynamics of the receiving stream and river channels. Potential movement of contaminated sediments. Especially near existing decant points and the proposed discharge points, the local sediments either have or may receive contaminants from the process. These may move further downstream under the new base flow regimes proposed.
Geohydrology	
Dewatering aquifers through abstraction of AMD	Potential reduction in groundwater quantities relied upon by water users. Reducing pressure through dewatering in mine voids and dolomite solution cavities – potential for collapse (geology instability)
Discharge of treated water in to the receiving environment	Seepage of discharged water back into groundwater environment – quality impact due to high salt load and waste of energy due to the recycling of water.
Storage of sludge produced by the treatment of AMD	Seepage of sludge and TSF mixture into groundwater environment – quality impact. Different quality impacts for each basin Deposition of sludge into Wes Wits Pit might have negative water quality impact
Air Quality	
Storage of sludge on existing TSFs	Elevated concentration of PM10, PM2.5 particulate matter in the atmosphere due to the deposition of the sludge on tailings facilities.
Heritage and Culture	
Construction of pump infrastructure	May cause alteration, damage to or destruction of historical buildings and structures older than 60 years

Environmental Aspect	Potential Impact
Discharge of treated water into rivers	Potential increases in water flow due to discharge may impact on heritage resources that could occur downstream and near river banks Potential increases in water flow due to discharge may impact on intangible heritage aspects such as baptism sites located in or near river Increased flow into the Tweelopiespruit may change aspects of the COH WHS
Human Health	
Treated water being discharged into the environment	Possible health impacts associated with the exposure to surface water and soil should decanting take place - sulphates, nitrates, , heavy metals, radionuclides
Radiation	
Radionuclides in the receiving streams due to the treated water discharge	Potential health impacts to humans as well as animals exposed to the water.
Socio-economic	
Potential increase in employment opportunities	People in the surrounding communities are hired during the construction and operational phases of the project
Operational costs required to maintain and run the HDS plants	Increased expenditure on the short term solution which is funded by the government
Potential change in water quality downstream of the receiving streams	Economic and health impacts may result on downstream water users
Soil	
The use of treated water for irrigation	Potential to affect the soil quality negatively. May increase the soil salinity. Potential to reduce or affect crops.
Ecology	
Discharge of water into rivers	During this phase, the water levels of the rivers

Environmental Aspect	Potential Impact
	and streams receiving discharged water will rise, permanently inundating previously seasonally wet areas and temporarily flooding areas that previously remained dry throughout the wet season. During the operational phase of this proposed project a variety of impacts will be associated with water quality. The ecological flows will be affected in that the base flows will be higher year round as a result of the proposed discharge. The impacts associated with water quality will be determined during the Environmental Impact Assessment study. The potential impact of treated water on the localised environment needs to be determined as water treatment options have not supplied effluent properties in terms of TDS, and temperature. The cumulative and chronic impacts of treated water needs to be addressed in terms of the natural fluctuations of water quality as well as the possibility for the presence of persistent elements including a variety of metals.

9 PLAN OF STUDY FOR EIA PHASE

The purpose of an EIA is to investigate the potential negative and positive impacts of a proposed project's activities on the environment. The objectives of this EIA process are:

- To ensure that the environmental impacts of developments are taken into consideration in a decision to approve or reject an application;
- To promote sustainable development;
- To ensure activities undertaken do not have a substantial detrimental impact on the environment and/or to reduce/mitigate those impacts;
- To ensure public involvement;
- To regulate the development; and
- To provide a process aimed at enabling authorities to make more informed decisions, especially in respect of their obligation to take environmental considerations into account when making those decisions.

9.1 Approach

As illustrated in Table 9-1, the Scoping and EIA is part of an integrated approach to obtain environmental authorisation to proceed with the immediate and short term interventions for the AMD project. It is a legal requirement which the TCTA needs to adhere to.

There has been criticism of the process in stating that the project has been decided upon and that people are merely going to be commenting on an agreed project and that the findings of an EIA process are irrelevant. Digby Wells is, however, proceeding with the EIA process in gathering information on the project as proposed and trying to understand its impacts and will then be giving recommendations on aspects which it feels could and should be changed. This process will also give the authorities a chance to hear suggestions and comments from interested and affected parties. It will also give the authorities an independent view of the impacts and implications of this project.

It is likely that the construction of the water treatment plants in the Western and Central Basins will commence prior to the finalisation of the EIA. Should this be the case certain of listed activities under NEMA will be triggered. Various options for the approval of these activities were considered.

It is possible that other interpretations of the provisions of NEMA may avoid the implication of unlawful activities, or that exemption from the provisions of NEMA may be granted.

SCOPING PHASE

- Consultations with I&APs
- Information sharing meetings
- Identification of environmental issues &concerns
- Identification of project alternatives
- Compilation of a draft Scoping Report
- Public review of the draft Scoping Report
- Submission final Scoping Report to the DEA

This report forms part of the Scoping Phase of the EIA process.

EIA PHASE

- Assess significance of potential impacts
- Evaluate impacts of project alternatives
- Compilation of an Environmental Management Programme
- Compilation of a draft EIA Report
- Public review of draft EIA Report
- Submission of final EIA Report to DEA

ENVIRONMENTAL AUTHORISATION

- Decision taken by DEA
- Decision made known to I&APs
- Provide I&APs with an opportunity to appeal against the decision

Table 9-1: Phases of the EIA process

9.2 Public Participation during the EIA phase

Public participation will continue during the EIA phase and will allow I&APs the opportunity to provide input into the process as well as raise issues regarding the proposed project. The PPP during the EIA phase is detailed below.

9.2.1 On-going stakeholder engagement

On-going consultation will take place during the EIA phase with those I&APs identified in the scoping process. This engagement will include responding to any additional issues raised by I&APs during the EIA phase. If needed meetings with key stakeholders will take place. If required updated information documents regarding the project will be developed and sent to I&AP on the database.

9.2.2 Meetings

Public feedback meetings will be held once the draft EIA/EMP report is ready for public review. These meetings will include one meeting per basin. The aim of these meetings will be to present the findings of the EIA and to present the EMP report. Depending on the effectiveness of the venues used during the scoping phase public meetings, the same venues will be used.

An EIA interest group meeting will be help with key stakeholders which were identified in the scoping phase. The aim of this meeting will be to present the EIA/EMP report and gather comments from these stakeholders.

The bi-monthly authorities meetings will continue to be held during the EIA phase. These meetings will be held to inform the authorities of progress made in terms of the EIA and to receive their inputs regarding the EIA process being followed.

9.2.3 Review of the Draft EIA / EMP

The draft EIA/ EMP will be placed in the public domain for public review this includes:

- Placing the document at public venues within the vicinity of the project area. The same venues will be used as during the scoping phase;
- CDs are to be mailed to key stakeholders;
- CDs to be mailed to I&APs who request the report; and
- The document will be placed on the Digby Wells website as well as the AMD short website.

The document will be made available for public review for the required 30 days. Advertisements will be placed in the relevant newspapers to inform the public of the availability of the Draft EIA/EMP report for public review.

9.2.4 Environmental authorisation decision

Once the authorities have made a decision with regards to the authorisation of the project all registered I&APs will be informed of the decision. An advertisement will also be placed in the newspapers used for the project, informing the general public of the decision.

9.3 EIA methodology

In order to clarify the purpose and limitations of the impact assessment methodology, it is necessary to address the issue of subjectivity in the assessment of the significance of environmental impacts. Even though Digby Wells and the majority of environmental impact assessment practitioners propose a numerical methodology for impact assessment, one has to accept that the process of environmental significance determination is inherently subjective. The weight assigned to the each factor of a potential impact and the design of the rating process itself, is based on the values and perception of risk of members of the assessment team, I&APs and authorities who provide input into the process. It is for this reason that it is crucial that all EIAs make reference to the environmental and socio-economic context of the proposed activity in order to reach an acceptable rating of the significance of impacts. It is not the purpose of the EIA process to provide an incontrovertible rating of the significance of various aspects, but rather to provide a structured, traceable and defendable methodology of rating the relative significance of impacts within a specific context.

The methodology employed for the EIA is divided into two distinct phases, namely impact identification and impact assessment.

9.3.1 Impact identification

Impact identification is performed by use of an input and output model, which serves to guide the assessor in assessing all the potential instances of ecological and socio-economic change, pollution and resource consumption that may be associated with the activities required during the construction, operational, closure and post-closure phases of the project.

Outputs may generally be described as any changes to the biophysical and socio-economic environments, both positive and negative in nature, and also include the product and waste produced by the activity. During the determination of outputs, the effect of outputs on the various components of the environment (e.g. topography, water quality, etc.) is considered.

During consultation with I&APs, perceived impacts were identified. These perceived impacts will become part of the impact assessment and significance rating in order to differentiate between probable impacts and perceived impacts.

9.3.2 Impact rating

The impact rating process is designed to provide a numerical rating of the various environmental impacts identified by use of the input and output model. The significance rating process follows the established impact/risk assessment formula:

	Significance = Consequence x Probability
Where	Consequence = Severity + Spatial Scale + Duration
And	Probability = Likelihood of an impact occurring

The severity, spatial scale, duration and probability of an impact occurring are assigned a rating out of seven as indicated in Table 9-2. The matrix calculates an overall significance rating out of 147. Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in the EMP.

The significance of an impact is determined by referencing the significance rating to the probability consequence matrix shown in Table 9-3 after which it is categorised into one of four categories, as indicated in Table 9-4.

Table 9-2: Impact significance rating

Rating	Severity		Spatial scale	Duration	Probability
	Environmental	Social, cultural and heritage			
7	Very significant impact on the environment. Irreparable damage to highly valued species, habitat or eco system. Persistent severe damage.	Irreparable damage to highly valued items of great cultural significance or complete breakdown of social order.	International The effect will occur across international borders.	Permanent without mitigation No mitigation measures of natural process will reduce the impact after implementation.	Certain/definite The impact will occur regardless of the implementation of any preventative or corrective actions.
6	Significant impact on highly valued species, habitat or ecosystem.	Irreparable damage to highly valued items of cultural significance or breakdown of social order.	National Will affect the entire country.	Permanent with mitigation Mitigation measures of natural process will reduce the impact.	Almost certain/highly probable It is most likely that the impact will occur.
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate.	Very serious widespread social impacts. Irreparable damage to highly valued items.	Provincial/regional Will affect the entire province or region.	Project life The impact will cease after the operational life span of the project.	Likely The impact may occur.
4	Serious medium term environmental effects. Environmental damage can be reversed in less	On-going serious social issues. Significant damage to structures or items of cultural	Municipal area Will affect the whole municipal area.	Long term 6 to 15 years.	Probable Has occurred here or elsewhere and could therefore occur.

Rating	Severity		Spatial scale	Duration	Probability
	Environmental	Social, cultural and heritage			
	than a year.	significance.			
3	Moderate, short-term effects but not affecting ecosystem functions. Rehabilitation requires intervention of external specialists and can be done in less than a month.	On-going social issues. Damage to items of cultural significance.	<u>Local</u> Local extending only as far as the development site area.	<u>Medium term</u> 1 to 5 years.	<u>Unlikely</u> Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur.
2	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with or without help of external consultants.	Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	<u>Limited</u> Limited to the site and its immediate surroundings.	<u>Short term</u> Less than 1 year,	<u>Rare or improbable</u> Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the project but has happened elsewhere. The possibility of the impact occurring is very low as a result of design, historic experience or implementation of adequate mitigation measures.
1	Limited damage to minimal area of low significance. Will have no impact on the	Low-level repairable damage to commonplace structures.	<u>Very limited</u> Limited to specific isolated parts of the	<u>Immediate</u> Less than 1 month.	<u>Highly unlikely</u> Expected never to happen.

Rating	Severity		Spatial scale	Duration	Probability
	Environmental	Social, cultural and heritage			
	environment.		site.		

Table 9-3: Probability consequence matrix

Significance										
		Consequence (severity + scale + duration)								
		1	3	5	7	9	11	15	18	21
Probability / Likelihood	1	1	3	5	7	9	11	15	18	21
	2	2	6	10	14	18	22	30	36	42
	3	3	9	15	21	27	33	45	54	63
	4	4	12	20	28	36	44	60	72	84
	5	5	15	25	35	45	55	75	90	105
	6	6	18	30	42	54	66	90	108	126
	7	7	21	35	49	63	77	105	126	147

Table 9-4: Significance summary table

Significance		
High	**108- 147**	
Medium-High	**73 - 107**	
Medium-Low	**36 - 72**	
Low	**0 - 35**	

9.4 Risk assessment

During the scoping phase of the project a Risk Assessment was conducted to identify the potential risks to the project.

The following objectives were set for the Risk Assessment:

- To review and rank the environmental and social risks related to the treatment of polluted water from the West, Central and Eastern Witwatersrand Basins;
- To develop mitigation measures, with action plans, for the key risks; and
- Determine the detail and the scope of specialist inputs and investigations required for the permitting process of the project through the identification of these risks

Twenty-three unwanted events were identified during the Risk Assessment (Appendix M). The risk associated with each unwanted event was assessed, and a ranked list of risks has been developed. Nine risks were rated as high, and for these additional mitigatory measures have been defined.

9.5 Impact mapping

Through a series of integration meetings and workshops the specialists have been provided with the opportunity to define their study boundaries and how they relate to the other specialists. In so doing a level of integration has occurred and information dependencies have been determined.

This process also provided valuable insight into determining which activities would have environmental aspects associated with them which may lead to environmental impacts.

The proposed short term intervention for the treatment of AMD can be divided into 2 main project phases, namely; the construction phase and the operational phase. These phases were both considered during the compilation of the ToRs and require specific studies to assess the impacts associated with them. The phases and the specialist studies required for them are detailed below. The comprehensive Impact Map is attached in Appendix N.

9.5.1 Construction phase

It was confirmed that during the construction phase of the proposed project that the environmental aspect of land transformation, job creation and spending may need to be investigated further.

The table above was used to assess the various project inputs and as a team it was decided which aspects were significant or not and the significant ones formed the basis for deciding which aspect should be considered in further studies.

Land transformation was seen to have an influence on the heritage landscape of the project areas and the investigation into this was deemed necessary. This applies to all the areas of surface disturbance – pipelines, HDS plant and support infrastructure.

The creation of jobs was seen to link to the characterisation of the social environment of the study area and this would need to be studied to identify possible impacts. The capital expenditure as well as the operational costs for the project are linked to the economic analysis of the project.

9.5.2 Operational phase

It is during the operational phase that a number of activities with associated environmental aspects and impacts will take place. These can be linked to the 4 main project activities as described in chapter 2. The Main operational activities for the project can, therefore, be summarised as follows (Table 9-5):

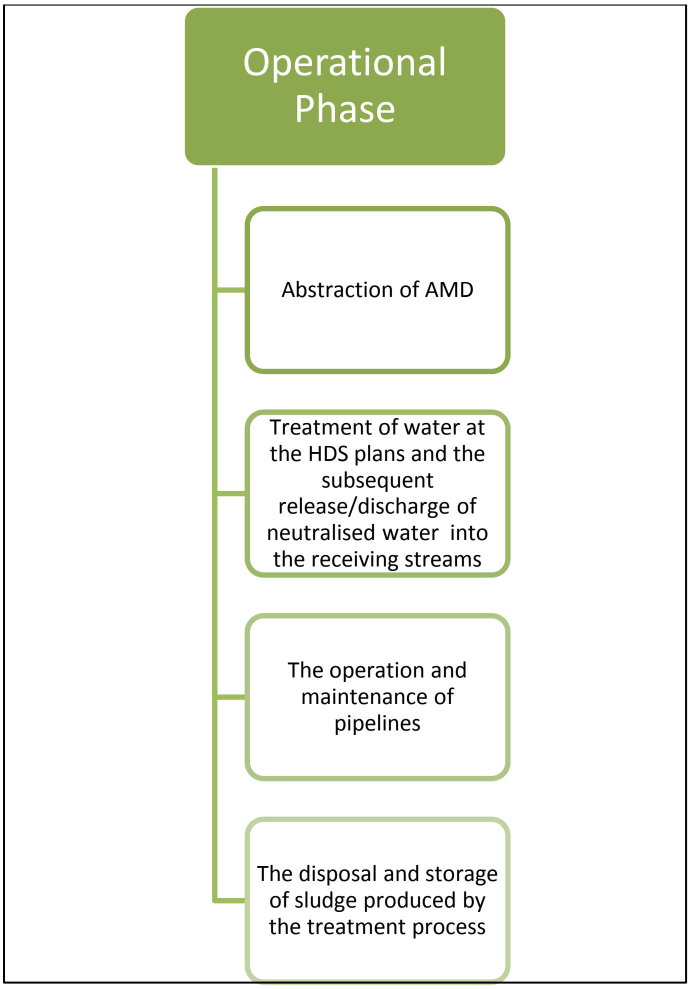

Table 9-5: Main project activities for the operational phase

Related to these activities are a number of environmental aspects which in turn may have environmental impacts. The aspects and potential impacts for each of the operational activities were taken into consideration when the Terms of References (ToR) for the specialist studies were compiled.

9.6 Specialist Terms of References

The specialist ToRs generally describe the purpose and structure of relevant specialist studies required for a project. The specialist studies that will be undertaken as part of the EIA Phase for the proposed immediate and short term interventions for the AMD Project are discussed in detail below.

9.6.1 Study areas

The proposed short term treatment project will aim to neutralise free and metal acidity in the AMD to near-neutral pH. This neutralisation and aeration will allow for the removal of metals from the AMD in the form of metal hydroxides, including uranium. The proposed treatment will result in partial desalination of the water by removing between 40 and 60% of the dissolved salts. The neutralised water to be discharged will still be saline and an increase in TDS of the receiving rivers is likely.

The surface water quality environmental aspects will, therefore, include:

- High acidity and low pH, dissolved metals, oxygen deficiency and elevated temperatures in the upper reaches of water courses;
- Increased salinity of receiving river systems; and
- Associated changes in Vaal River system management affecting system yield and raw water importation requirements.

These changes in water quality may have direct impacts on water users and the natural environment and, thus, is viewed as the determining factor in classifying the study areas of the three basins.

The study areas for the relevant specialist studies for the three basins are described in more detail below.

9.6.1.1 Western Basin

The Western basin is distinct from the other two basins in that the mining void has already filled, and uncontrolled decant to the Tweelopiespruit has been occurring since 2002. As expected the upper reaches of this stream are clear but sterile, characterised by very low pH, low oxygen concentration, high salinity and elevated temperature.

Up until 2010 there was no evidence of the effect of the mining decant on water salinity at the Department of Water Affairs (DWA) weir A2H019 on the Bloubankspruit. This was surprising, since for a normal river reach, the low flow salinities at this point were expected to have more than trebled and the flow-weighted salt load entering Hartbeespoort Dam should have increased by 35%. It is, however, understood that for the last 9 years the water from the Rietspruit and Bloubankspruit has been recharging into the Zwartkrans groundwater compartment which was preventing the decant water from entering the Crocodile River. In 2010, however, the compartment filled up and the water is flowing on surface in the

Bloubankspruit. This has caused a 27% increase in the salt load entering the Hartbeespoort Dam.

Based on this information the study area for the Western Basin will include the Tweelopiespruit (from the decant point), the Rietspruit and the Bloubankspruit, as well as the Crocodile River all the way to the Hartbeespoort Dam.

9.6.1.2 Central and Eastern Basin

Abandonment of mine workings in the Central and Eastern basins has led to a gradual rise in water levels in the mining voids, which if left unattended would, as in the Western Basin, also eventually decant with similar adverse impacts on surface water quality. The short term intervention includes the abstraction of water to prevent the water level in the mining voids from rising above the ECL and treat the AMD at a HDS plant on surface. Hence AMD decant would be prevented from occurring in the Central and Eastern Basins.

Due to the proposed treatment of AMD it is envisaged that, In the case of the Central and Eastern basins, a substantially increased salt load would enter Vaal Barrage, thereby, increasing the amount of water required from the Vaal Dam to dilute the outflow from the Vaal Barrage to protect the water quality supplied by downstream water boards and municipalities. These management measures when implemented will have economic, social and environmental effects, which need to be investigated. The study area for the Central and Eastern Basins would include the receiving streams as well as those rivers they form tributaries to, as well as the Vaal River, from the respective confluences to the Vaal Barrage.

9.6.2 Specialist studies

Through the identification and categorisation of the potential impacts of the project, the following specialist studies were deemed necessary for the EIA phase of the AMD Project:

- Surface water assessment, including:
  - Surface water quality; and
  - Surface water quantity
- Characterisation of the social environment;
- Radiation study;
- Community Health Impact Assessment;
- Ecological assessment, including:
  - Wetland investigation;
  - Fauna & flora assessment; and
  - Aquatic assessment.
- Geohydrological assessment;

- Archaeology and Heritage assessment;
- Economic analysis;
- Agricultural assessment;
- Technology assessment; and
- Air quality assessment.

These studies and their proposed methods are discussed in detail below.

9.6.2.1 Surface water assessment

The surface water assessment will integrate the specialist investigations relating to water quality and water quantity potential changes as a result of the proposed short term treatment of AMD. It is based on this assessment that other specialist studies will be informed as to what the extent of their investigations needs to be as it is generally accepted that the potential impacts associated with the project will be the most significant on the surface water through an increase in water quantity and a decrease in quality (salinity). It is due to these potential impacts on surface water that other direct and indirect impacts in terms of the biophysical and social environment may occur.

9.6.2.1.1 Scoping issues

The following Risk Assessment issues relevant to surface water were raised during the scoping phase:

- Water shortage in the upper Vaal catchment from 2014 onwards – Risk rating of 21[7];
- The EIA shows that it is better to do nothing than to partially treat the water – Risk rating of 19;
- The EIA fails to identify the consequences of the changes in water quality and quantity – Risk rating of 14; and
- Irrigation impacts – Risk rating of 14.

A number of issues regarding surface water were raised by I&APs during the scoping phase. These issues have been reviewed and taken into consideration during the compilation of the surface water study ToR. The following key issues were identified:

- The quality of the water being released;
- The impacts of pumping neutralised water into the streams from a water quality perspective, specifically due to the high sulphate levels;

[7] Note: Risks were rated from 1 to 25 in terms of severity

- The increase in the volume of water in the receiving streams and the impacts associated with this. Issues were raised around the flooding of the streams and impacts on water front properties and infrastructure;
- Increase in base flow and the impacts on the receiving systems;
- Impacts on ecology associated with the release of neutralised water; and
- The effects on the Vaal River System with regards to water availability and dilution due to the increase in salinity.

9.6.2.1.2 Potential impacts the project may have in this specialist area

The following impacts may be associated with the project in terms of surface water (Table 9-6).

Table 9-6: Potential Impacts on surface water

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ No significant impacts on the surface water environment.
2. The construction and operation of the HDS Plants and the discharge of neutralised water in the environment	■ Impact on surface water quality due to the high salt loads of the water being discharged. ■ The increase in water volumes may cause the inundation of riparian property (incl. informal areas, footpaths, access roads, etc.). ■ Flooding due to the increase in the volumes discharged may impact on low level bridges, structures, etc., affecting level of service and stability of the structures. ■ Channel stability may be impacted on due to increase flows, especially in upper reaches of study area. Higher base flows may change the dynamics of the receiving stream and river channels. This will support a study on impacts on river geomorphology. ■ Potential movement of contaminated sediments through the increase in water flow. Especially near existing decant points and the proposed discharge points, the local sediments either have or may receive contaminants from the process. These may move further downstream under the new base flow regimes proposed.

Project activity	Potential impacts
	■ Changes in duration and depth of inundation in wetlands. This will support studies on impacts on wetlands. ■ Potential changes in aquatic habitat. Changes in base flow will change velocity and depth conditions in the receiving streams, with the possibility of changes in habitat conditions. ■ General impacts on surface water resources. The magnitude of change in monthly and annual catchment yield will be assessed within the study area.
3. Construction and operation of pipelines	■ No effect on surface water other than short-term local risk of pipe rupture
4. The disposal of the sludge	■ Insignificant effect on surface water quality ■ Potential stormwater spills from the TSFs. The addition of HDS sludge to existing TSFs may change their stormwater management requirements, potentially increasing the risk of spillage from the TSFs.

9.6.2.1.3 Method and objects of the study

The objectives of the surface water assessment will be to:

- Characterise the current receiving environment with regard to:
  - The existing hydrology of the receiving streams;
  - The existing quality of the receiving streams;
  - The geomorphology of the streams;
  - Sensitive areas within these systems;
  - The current yields of the rivers and their contribution to the overall systems they exist in.
- Assess the effects of the short term intervention (I.e. pumping from the ECL followed by TDS treatment), in terms of:
  - Water quality:
    - The extent of the decrease in water quality downstream, specifically with regards to salinity and heavy metals;

- The effects on water quality during different seasons;
- The effect on water quality should the treatment plants not function optimally; and
- The effect on the Vaal System and yields.

- Water quantity:
  - The effect on hydrology of the streams taking into consideration seasonal changes;
  - the extent of this change downstream;
  - How the geomorphology of the streams will be altered with the increase in flow relating to erosion and deposition of the channels; and
  - Identify areas which could be vulnerable to flooding.

- Assess the impacts of the no-go option (i.e. the consequences of uncontrolled decant) on water quality and quantity with respect to the factors considered for the treatment option; and
- Assess the implications of discharging the water in the Western Basin into an alternative catchment.

The steps to be followed to investigate surface water quality are outlined below.

Characterisation of the receiving environment

With regard to the Tweelopiespruit, flow estimation and water quality assessments will be made to identify where the saline decant water is being lost to dolomitic compartments, complicated by irrigation abstractions.

The short-term monitoring data, together with data routinely collected by the Department of Water Affairs (DWA) at established monitoring points further downstream, will be assessed and plotted to categorise the receiving environment near to the points of discharge.

There is a considerable amount of information published for the catchments and rivers in each of the basin study areas and it is intended to utilise this data to describe the receiving environment. Data including the following will be sourced:

- Published data (e.g. WR2005) and publicly available data bases (e.g. DWA hydrological records);
- Data from utilities and local government; and
- Recent data will also be sought for the main discharges and abstractions in the receiving streams.

The data will be collated and used to characterise the water resources and stream flow in terms of statistical descriptions of monthly and daily stream flow and rainfall at a quaternary level. This will be supplemented with an assessment of urban runoff responses and contributions to river flow. This will be largely based on anticipated responses from paved areas of the quaternary catchments.

A short-term surface water quality monitoring programme will be established for the upper reaches of the receiving water streams. Variables measured in situ will include temperature (T), dissolved oxygen (DO), pH and electrical conductivity (EC). Laboratory analyses will include key chemical constituents, metals and micro-organisms.

With respect to the hydrology of the streams, grab samples of bed sediment will be collected for testing particle size distribution and for pollutants including heavy metals and radio nuclides. This will indicate the likelihood of sediments being transported downstream which will be a concern if the proposed AMD treatment process still released these pollutants.

A component of the surface water systems that needs to be described is the flood risk along the watercourses. This will not be a detailed flood line study, but will consider potentially vulnerable areas that will be analysed on a site by site basis. These sites will be identified by both site visit and desk level (GIS) analysis, as well as input from the characterisation of the social environment.

Assessments

The monthly flow data will form the basis of the hydrology used to assess maintenance of ecological flows. The input from the surface water quantity stream will be establishing both the maintenance hydrology and the stream hydraulics at representative sites selected with the aquatic specialist. This will include depth and velocity profiling of the sites under low flow conditions, and hydraulic modelling for the high flow conditions. A flow rating curve will then be developed for each site and, with input from the aquatic specialist, the ecological flows will be estimated;

The present channel stability and susceptibility to erosion will be assessed and will include taking soil samples from the river bed and banks and testing for cohesiveness and plasticity. The rating curve will be used to estimate the shear stress and erodibility of the bed and banks.

Additionally, the same hydrology will also be used to assess potential changes to wetland water levels and area of inundation. In conjunction with the wetland specialist, the current areas of inundation will be identified for key wetland areas identified by the wetland specialist. It is intended to develop a basic water balance for the wetland(s).

The present day catchment flood responses will be calculated and compared to the hydraulic capacity of the site to determine the impacts on the identified sensitive or vulnerable sites to flooding.

Through the hydrology assessment it will be possible to determine the significance of the change in water quality due to the discharge of neutralised water. The significance will, therefore, be measured by:

- Increasing risk of channel scour and the likelihood of a noticeable change in the natural balance of the present system;
- The change in normal depth and/or velocity such that a change in habitat occurs; and
- The change in either normal flow of flood flow regimes will affect the stability, maintenance or level of service of a river structures (e.g. bridge, access road or a farm dam).

The assessment of the no-go alternative with regards to surface water quantity will involve identifying the point of discharge to the receiving streams by consulting the geohydrologist in terms of the proposed decant points. The rate of decant may be different to the planned pumping rates in the proposed treatment scheme. However, it is intended that the same sample sites are used and the same baseline hydrology will apply unless the decant points will affect different streams or are a considerable distance from the proposed HDS Plant discharge points.

With regard to surface water quality, salinity modelling will be completed for each of the basins. The following scenarios will be modelled:

- The current status i.e. before treatment;
- The short term intervention (HDS treatment) option; and
- The no-go option i.e. uncontrolled decant;

The models used will be both the WQT Hydro-salinity Model and Water Resources Planning Model (WRPM). The WQT model will be used to simulate local impacts for a few representative historical hydrological sequences while the WRPM will be used to simulate salinity and water resources in the wider systems. Salinity is extremely important in view of the large number of urban, industrial and irrigation users that will be affected and the large economic consequences associated with changes in salinity levels. Statistics and plots will be derived for each option and comparisons will be made with Resource Water Quality Objectives and the results presented.

9.6.2.1.4 Project team

The surface water assessment will be completed by Dr. Chris Herold (quality) and Stuart Dunsmore (hydrology).

9.6.2.2 Characterisation of the social environment

The characterisation of the social environment is essential for the successful completion of other relevant specialist studies. It is also dependant on the results of the surface water study as these will determine the significance of the impact on people living within the study area.

9.6.2.2.1 Scoping issues

The risk assessment identified that the release of neutralised water may have a "Social Impact" and was ranked as a moderately significant risk associated with the project.

Based on the input by I&APs and authorities during the scoping phase, the following key issues were noted:

- Job creation – The question of whether the project would create jobs, and if so, how many, was asked. I&APs see the project as potentially having a positive impact as far as job creation is concerned;
- Economic impacts - (both of the project and of the no-go option);
- Human and animal health impacts;
- Impacts on agriculture;
- Impacts on groundwater; and
- Risks associated with flooding due to increased water quantities in the affected watercourses.

As mentioned above, with the exception of job creation and economic benefits related to spending during the construction and operation of the plants, these impacts are being investigated by other specialist studies forming part of this project.

9.6.2.2.2 Potential impacts the project may have in this specialist area

The social impacts of the project are summarised in Table 9-7 below.

Table 9-7: Potential impacts on the social environment

Project activity	Potential impacts
1. Construction of the HDS Plants	■ Temporary job creation ■ Temporary economic benefits related to project spending
2. Operation of the HDS Plants	■ Relatively limited job creation ■ Relatively limited economic benefits related to project spending ■ Impacts related to the change in water quality downstream, both for people using surface and groundwater ■ Perception issues for people irrigating with mine water that could be seen as contaminated.

Project activity	Potential impacts
3. Construction and operation of pipelines	■ Relatively limited job creation ■ Relatively limited economic benefits related to project spending
4. Deposition of sludge	■ Possible impact on people living close to the TSF sites through dust emmisions and contamination of groundwater

9.6.2.2.3 Method and objectives of the study

The objectives of the characterisation of the social environment are as follows:

- To establish a baseline of land uses, communities and economic activities along the potentially impacted watercourses and around the TSFs constituting the study area;
- To determine whether abstraction from the affected watercourses for irrigation and livestock watering is occurring currently. Other water uses (e.g. recreational or cultural uses) along the potentially impacted watercourses will also be documented;
- Based on other studies and their results to quantify the impacts associated with the proposed project; and
- Provide a qualitative assessment of the social impacts that are likely to occur if the proposed intervention is not implemented – i.e. if uncontrolled decanting of untreated mine water occurs (or continues) from various shafts in the Western, Central and Eastern basins (no-go option).

Characterisation of the receiving environment

The social environment will be characterised through the completion of the following tasks:

- Database design and data collection - one of the main deliverables of the social specialist study will be a geo-referenced database of land uses, communities, economic activities, water abstraction and other water uses in the study area. The database will be developed in the appropriate electronic format to allow for geospatial referencing and will comprise the following data fields:
  - Type of feature e.g. land use, communities, infrastructure and land marks
  - The cadastral land portion on which it is located, and the title deed holder of that land portion;
  - In the case of communities that may rely on water from the affected watercourses, indicators of potential vulnerability to economic and/or health impacts that could arise from a change in water quality or quantity; and

  - For points at which water is abstracted from the potentially affected watercourses or groundwater, information on the uses of abstracted water, the rate and seasonality of abstraction, etc.

- Visual inspection of available aerial imagery - each land use, community or water use in the study area that is visible on the aerial imagery will be given a unique identifier, and its characteristics as discernible from the images will be captured in the electronic database;
- Data from secondary sources - where relevant, secondary data sources will be used to further populate the database with regard to relevant attributes of land/ water uses or communities that are not readily apparent from aerial imagery;
- Field verification - a field verification or ground-truthing exercise will be undertaken by a team of suitably trained fieldworkers; and
- Interviews with communities and water users - due to the sensitivities surrounding the project, interviews with communities in the study area will be undertaken, within clearly defined boundaries and with a clear mandate.

Assessments

Once the database has been fully populated, it will be subject to quantitative analysis to generate relevant descriptive statistics (such as the numbers of potentially affected households, etc.). Informative maps will also be produced, where applicable, to reveal spatial trends and patterns in the study area.

The main aim of the social characterisation will be to provide information on social aspects of the receiving environment that would be used by most of the other specialists (namely, the economic impact assessment, health impact assessment, radiological impact assessment, heritage impact assessment and hydrological impact assessment).

The only “purely” social impacts requiring assessment as part of this specialist study are impacts related to job creation and spending during construction and operation of the HDS plants and pipelines. These impacts will be assessed based on available project information (required workforce, capital expenditure budget, etc.) and will be subject to a formal rating in terms of expected duration, geographical extent, probability, intensity and overall significance.

The social specialist study will also address the issue of cumulative social impacts that may arise from the combined effect of the project on various aspects of the biophysical and economic environment.

9.6.2.2.4 Project team

The assessment will be undertaken by Jan Perold of Digby Wells Environmental.

9.6.2.3 Radiation study

The radiation study and the prediction of impacts associated with radiation issues are highly dependent on the results of the social characterisation and the water quality assessment. The database to be compiled during the interview process will be used to identify possible pathways and, thereby, identify impacts associated with radiation exposure.

9.6.2.3.1 Scoping issues

The risk assessment identified radiation pathways and the adequate identification of these as a high risk (21) to the project. Although information is available it will be necessary, in conjunction with other studies (health and social characterisation) to determine the possible radioactivity of the discharged water and how this will impact on water users directly or indirectly.

The following issues were raised by I&AP regarding radiation:

- The uranium levels within the water discharged – Questions were asked about how much uranium would be in the discharged water;
- The impacts of uranium in the discharged water; and
- The uranium levels in the sludge and the possible migration into groundwater through seepage.

9.6.2.3.2 Potential impacts the project may have in this specialist area

Table 9-8 details the potential radiation impacts on the receiving environment.

Table 9-8: Radiation impacts

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ None
2. The construction and operation of the HDS Plants and the discharge of neutralised water in the environment	■ Possible radioactive contamination of the discharged water, which in turn may have health impacts to humans.
3. Construction and operation of pipelines	■ Contamination of soil and surface water should the pipelines spill.
4. The disposal of the sludge	■ Should the sludge be radioactive and the physical properties are such that it can be distributed by wind there is a possibility of health impacts to nearby communities as well as possible groundwater contamination.

9.6.2.3.3 Method and objectives for the study

The aim of the radiation study is to determine the radiation doses that the public will receive from the resulting release of AMD water (treated or untreated).

The objectives of the assessment can be defined as follows:

- Provide a description of the relevant legal framework with reference to national legislation, conventions and guidelines;
- Ascertain and describe the existing radiological background dose conditions in the project area based on available information;
- Identify and quantify the radiological pollution sources associated with the treatment and release of the neutralised AMD effluent to the various catchment areas;
- Assess the results of the sludge characterisation and determine the impacts thereof;
- Determine the boundaries of where the release of treated or untreated AMD might contaminate the catchment area;
- Assess the cumulative environmental and public exposure radiological doses and risks for all relevant pathways to the potential receptors for both the treated and untreated effluent release cases; and
- Provide input, together with other specialists, into the future management measures required.

Characterisation of the receiving environment

A broad estimation of the radiological status of the respective catchment areas (for all three Basins) will be obtained through the collection of existing relevant radiological data (water and geological) and additional data through a sampling strategy.

Data will be collected by communication with DWA (especially the Water Research Laboratory), Council for Geosciences, the National Nuclear Regulator, licensed mines within the respective areas and relevant departments that conducted EIAs or gathered radiological data for the respective catchment areas.

To determine the current extent of radiological contamination from the Western Basin water treatment process, samples of surface water, sediment and biota will be collected from water sources (streams, rivers and other possible surface water bodies influenced by AMD effluent release) between the release point in Tweelopiespruit up to the Hartbeespoort Dam. Groundwater will also be sampled from borehole areas that rely heavily on the water for irrigation and other applications. The locations of these boreholes, however, will be determined through the social characterisation and interviews that are undertaken as part of the specialist study.

Treated and untreated AMD water just before release in the river will also be sampled in order to determine the efficacy of the treatment process and to gain information on the no-go option. Radionuclide analyses will be performed on all the gathered samples to determine the concentrations of uranium and its daughter products. The significance of the daughter products in the samples is currently unknown. A relationship between uranium and the daughter products must, therefore, be established in order to defend any dose related assumptions made later on in the dose assessment. The sampling programme will consist of the collection of 20 water samples and 5 sediment samples.

Since water release in the Central and Eastern Basins has not yet taken place, it is expected that interested parties e.g. Department of Water Affairs, would have started with a similar sampling regime.

Assessment

The main task of this study component is to determine the public doses and resulting radiological risks, associated with the AMD treatment operations and the release of the treated or untreated water. It will make use of the data gathered during the interview process as part of the social characterisation, as well as the water quality results from the Surface Water Study. The dose assessment will cover scenarios associated with the use of the water in the catchment areas. While the main area of concern will be the catchment area of the Western Basin, the assessed results will be extrapolated to the other catchment areas as well.

The resulting radiological doses will be converted to a health risk and shared with the Health Study.

Until such time as the physical and chemical characteristics as well as the sludge disposal sites are known, the radiation assessment will not investigate the possible impacts associated with air quality and the inhalation of particles emanating from the tailings storage facility or from potential groundwater contamination.

9.6.2.3.4 <u>Project team</u>

The Project Team will consist of Dr. Dawid de Villiers (project leader), Dr. Gert de Beer (peer-reviewer), Gert Liebenberg, Rean Swart and Neels Boshoff.

9.6.2.4 Community Health Impact Assessment

The Community Health Impact Assessment (CHIA) will primarily identify and assess the possible human health impacts associated with the proposed treatment of AMD and the release of the neutralised water into watercourses. In order to achieve this, the CHIA is highly dependent on the information gathered and the findings of, the social characterisation and the radiation study.

9.6.2.4.1 <u>Scoping issues</u>

The risk assessment identified that the impact on community health is a medium risk. It was determined that this risk would be further investigated during the EIA phase of the project and that a CHIA would be required to quantify this risk.

The following issues were raised during the scoping phase of the project as were used to define the study further:

- The suitability of the water for human and animal consumption during immediate and short term;
- Impacts on human health if water is consumed or used for bathing;
- The health impacts related to radiation;
- Human health-related impacts of discharged water, especially during low-flow periods; and
- Health risks, including chronic health risks of high sulphate levels on humans and animals (mutagenicity, teratogenicity and estrogenicity).

9.6.2.4.2 Potential impacts the project may have in this specialist area

Table 9-9 details the potential impacts the project may have on human health.

Table 9-9: Potential Impacts on community health

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ No impacts are expected for this project activity
2. The construction and operation of the HDS Plants and the discharge of neutralised water in the environment	■ Health impacts may occur should exposure to surface water occur. ■ Exposure to contaminated groundwater from boreholes may have potential impacts on human health; ■ The use of the discharged water for irrigation may have effect crops/produce as well as the soil. This will have an indirect impact on human health.
3. Construction and operation of pipelines	■ Should pipeline failure occur it could expose people to harmful substances with associated health impacts.
4. The disposal of the sludge	■ Run-off and seepage of wet sludge may contaminate surface and groundwater, resulting in potential exposure to sulphates, nitrates, heavy metals, radionuclides with associated health effects. ■ Exposure to dried sludge as suspended particulate matter may be inhaled and impact on human health.

9.6.2.4.3 Method and objectives of the study

The following objectives exist for the CHIA:

- To assess the health impacts associated with the proposed AMD project on people within the study area through the evaluation of health determinants identified in the various specialist studies. This will include:
  - Assessing the impact of high salt loads on humans; and
  - Assessing the impact of radionuclides on human health.
- Defining the extent of the health impacts within the study area; and
- Developing possible management measures to reduce the impacts.

Characterisation of the receiving environment

A community health and wellbeing profile will be developed using the data collected during the characterisation of the social environment. Use of national and local demographic and health information will also be made. During the characterisation of the social environment interviews will be held with people, groups or organisations during which information relating to the health of the people as well as identify practices that could compromise their health in the future e.g. drinking from the receiving rivers etc.

The information gathered during this process will include:

- Nutritional status;
- Disease profiles;
- Livelihoods;
- Potential exposure to pollutants such as particulate matter, heavy metals sulphates and nitrates, and radionuclides;
- Services;
- Social capital and culture; and
- Natural.

The health of people will be determined by the extent and distribution of the impacts relating to water quality and air quality. Receptors will, therefore, only be identified once the results of the surface water and air quality studies are known. Once received the results will allow for the identification of areas within the study are that may be affected by the proposed project. The social information relating to land use and economic activities will then be used to determine sensitive areas and within those areas possible receptors.

Assessment

The information gathered during the health baseline will be used to systemically determine the range of the potential health impacts due to the proposed project, their importance and where, when and how likely they are to occur.

A Human Health Risk Assessment will be completed once the results of the radiation assessment, water quality analysis and air quality assessment are known. The risk assessment follows a defined procedure to determine the risk potential. The procedure follows the following steps:

- Hazard identification - determines whether exposure to a particular substance may result in adverse human health effects;
- Exposure assessment - involves the determination of the emissions, pathways and rate of movement of a substance as well as its transformation and degradation in the environment. This information is used to estimate the concentration to which human populations are or may be exposed. The media (air, water, soil) that individuals may be exposed to are considered, as well as the route (inhalation, ingestion, dermal contact) of exposure;
- Toxicity assessment or dose-response assessment - is the estimation of the relationship between dose, or level of intake of a substance, and the incidence and severity of an effect, as based on previous epidemiology and toxicological studies; and
- Risk estimation or risk characterisation - all the information obtained in the previous three steps of the risk assessment to describe whether a risk to public health is predicted from exposure to the pollutant(s) of interest. This process may be qualitative or quantitative, depending on availability of benchmark levels.

9.6.2.4.4 Project team

The project team will include Ms Juanette John of the CSIR.

9.6.2.5 Geohydrological study

The geohydrological environment will be affected by certain project activities and in turn will affect other activities. The abstraction of AMD from the mining voids will cause a decrease in groundwater levels in the western basin and maintain levels at the ECL in the Central and Eastern Basin. The discharge of the neutralised water to the environment may also influence the groundwater regime through recharge. In addition the deposition of the sludge on the TSF may cause seepage into the groundwater with inherent quality impacts.

9.6.2.5.1 Scoping issues

The following summarises the key issues raised by the I&APs during the scoping phase:

- The methodology used to calculate the ECLs – questions were asked about how the ECL were calculated;
- The effect of heavy rainfall on the ECLs;
- Geological instability and formation of sinkholes in the Western Basin due to the lowering of the water levels;

- Interaction between the aquifers, particularly the dolomitic aquifers, and the impacts on these;
- The impact of the project on groundwater boreholes used in homes and for irrigation of crops – The issues raised dealt with both the change in water quality as well as the availability of water should the project commence;
- Water ingress and recharge into the mining voids;
- The impact on groundwater through the deposition of sludge on existing tailings facilities. Particular reference was made to the interconnection of the West Wits pit to underground voids; and
- The geochemistry and hazardous classification of the sludge produced.

9.6.2.5.2 Potential impacts the project may have in this specialist area

An understanding of the status of the current aquifer conditions and receiving environment is required to assess the potential impacts from each of these activities of the receiving groundwater environment and its users. The potential impacts are described in Table 9-10.

Table 9-10: Potential Impacts on groundwater

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ Dewatering aquifers that were a source of water supply over the last couple of years - since Western Basin filled up and started to decant. ■ Reducing pressure (through dewatering) in mine voids and dolomite solution cavities – potential for collapse (geology instability). ■ Dewatering in the Western basin will stop current decanting AMD water – positive impact in terms of water quality in rivers. ■ Western Basin dewatering might alter the natural groundwater flow direction and direct groundwater flow away from Cradle of Humankind – positive impact. ■ The lower the ECL the more energy needs to be spent on pumping out the water and the more water there could be to pump out.
2. The construction and operation of the HDS Plants and the discharge of neutralised water in the	■ Seepage of discharged water back into groundwater environment – quality impact due to high salt load. Waste of energy due

Project activity	Potential impacts
environment	to the recycling of water. ■ Seepage / spillage of untreated water onto surface – seep into groundwater environment with water quality impacts. ■ Manage discharge in various basins to ensure minimum water level and quality impacts on for example the Sterkfontein caves and other fossil caves in the area. Assess discharge of water into other basins or water management areas.
3. Construction and operation of pipelines	■ No impact unless spills occur.
4. The disposal of the sludge	■ Seepage of sludge and TSF mixture into groundwater environment – water quality impact. Different quality impacts for each basin. ■ Deposition of sludge into Wes Wits Pit might have negative groundwater quality impact.

9.6.2.5.3 Method and objectives of the study

The groundwater regime of the study area is well understood through years of fieldwork and monitoring, both during and after mining occurred. It is, therefore, not required for the geohydrological assessment to verify or collect further data in terms of the groundwater for the three basins. Existing data and research will merely be used to assess the influence the project activities may have on the groundwater of the area as well as conceptually illustrate the interaction of the variance activities. This data will be sourced from a literature review of some of the most recent geological, hydrogeological and AMD studies and will be presented in a form which can be understood by the audience the EIA intends to address.

The geohydrological assessment aims to fulfil the following objectives:

- To characterise the aquifer systems using existing data, with particular reference to the dolomitic aquifers in each basin. The characterisation will address:
  - Extent of the basins;
  - Size and location of dolomitic aquifers;
  - Interconnection of aquifers;
  - Sources of recharge;
  - The local near surface groundwater regime over which the TSFs exist;

    - The quality of water within the mine voids with particular reference to salt loads and heavy metals; and
    - Water users in the study area.
- Develop a conceptual hydrogeological model for each basin by reviewing historical reports and numerical models. Visual aids will be developed to assist with presenting the conceptual model for each basin;
- With the use of the conceptual model evaluate the current basin water balance and evaluate the amount of discharged water that will potentially seep back to the groundwater;
- To estimate the size of the cone of dewatering that could potentially be formed due to the mine dewatering and what impact this may have on groundwater users within the impact zone;
- Assess the impacts on the groundwater of the following:
    - Disposal of sludge on existing TSF;
    - Abstraction of AMD water;
    - Geological stability impacts focusing on potential sinkhole formation;
    - Discharge of neutralised water with regard to recharge; and
    - Water users.

Characterisation of the receiving environment

A literature review will be conducted of available hydrogeological information for the three basins in order to characterise the groundwater environment in relation to the proposed project. This will involve a number of tasks, which are listed below.

- All available and relevant information on studies conducted on all the basins will be collected to understand the current status of the groundwater water quality and quantity, particularly in the vicinity of the abstraction shafts, treatment plants, sludge deposition areas and water discharge areas;
- Groundwater use data, in relation to the three basins, will be collected through the social characterisation and The WARMS data base which is managed by the Department of Water; and
- Meetings with groundwater specialists and authorities involved with the studies in the basins.
- Collection of recent monitoring data. The Department of Water Affairs (amongst others) is conducting regular groundwater and surface water monitoring activities in terms groundwater level and quality.

Assessments

The compilation of conceptual groundwater models [8] for each of the basins will be compiled using the data collected. The conceptual model will aim to describe the groundwater environment in terms of the following:

- Aquifers - these are rock units or open faults and fractures within rock units that are sufficiently permeable (effectively porous) to allow water transfer or storage. This will include:
  - Defining hydraulic parameters such as storativity and transmissivity for each aquifer unit; and
  - Interconnections between aquifers and mine voids, pits (including that of West Wits) and dolomitic compartments.
- Precipitation, evapotranspiration and subsequently recharge characteristics;
- Runoff and groundwater head data which yields groundwater flow;
- Groundwater quality characteristics;
- Potential sources of AMD and recharge to the underlying aquifer units;
- Boundaries that result in the change or interruption of groundwater flow;
- Potential sensitive areas in relation to sinkhole development; and
- Hydrostratigraphic units - these are formations, parts of formations, or a group of formations displaying similar hydrologic characteristics that allow for a grouping into aquifers and associated confining layers.

Through the compilation of the model the potential recharge and discharge areas will be defined for each basin. This information will be particularly important for other studies when assessing the no-go option of the project.

The conceptual models will also assess the interaction of the sludge disposal facilities on the local groundwater of the area by defining the geochemical characteristics of the sludge and the likely interaction with the groundwater regime and possible groundwater users and seepage zones.

Through the compilation of the conceptual model the specialists will be able to identify and quantify the impacts associated with the AMD project. The cumulative impacts of the discharge of treated AMD water will be assessed by describing the regional interaction of pits and holings and the potential contribution to recharge of the mine voids. The assessment, therefore, generally aims to identify:

- The impacts of the dewatering to ECL (Western Basin) on:

[8] Description of the geological and associated aquifer characteristics – how they interact – how water moves and what may impact water quality and level

- Geological stability; and
- Groundwater users.

- The impacts the ECLs may have on shallow and deep aquifers and groundwater users; and
- The impacts of sludge deposition on the proposed tailings storage facilities and West Wits Pit.

9.6.2.5.4 Project team

The specialist groundwater assessment will be undertaken by Lucas Smith, Dr Robel Gebrekristos, Megan Edwards and Prof Kai Witthüser (external reviewer).

9.6.2.6 Archaeology and heritage assessment

In terms the project, those heritage resources that will mostly be affected are expected to include historical structures and buildings associated with the history of mining and possibly some change to the COH WHS.

9.6.2.6.1 Scoping issues

During the risk assessment, the main risk identified was the effect that AMD may have on heritage sites, specifically the COH WHS. The risk was rated as medium (19).

The following issues were raised during the scoping phase and have been considered during the compilation of the ToR:

- The effect of the project on the COH WHS – The issue of water volume and quality on the heritage site was raised.

9.6.2.6.2 Potential impacts the project may have in this specialist area

Potential impacts associated with the project are listed in Table 9-11.

Table 9-11: Potential Impacts the project may have in this specialist area

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ Construction of pump infrastructure may cause alteration, damage to or destruction of historical buildings and structures older than 60 years ■ Water abstraction may impact the COH WHS positively through the reduction of decant into the area.
2. The construction and operation of the HDS Plants and the discharge	■ Construction of HDS plant may cause alteration, damage to or destruction of

Project activity	Potential impacts
of neutralised water in the environment	historical buildings and structures older than 60 years ■ Potential increase in water flow due to discharge may impact on heritage resources that could occur downstream and near river banks ■ Potential increase in water flow due to discharge may impact on intangible heritage aspects such as baptism sites located in or near river ■ Increased flow into the Tweelopiespruit may change aspects of the COH WHS
3. Construction and operation of pipelines	■ Construction of pipelines may disturb or destroy heritage resources on route such as burial grounds
4. The disposal of the sludge	■ None

9.6.2.6.3 Method and objectives of the study

The objectives of the assessment are to:

- Describe the current environment in terms of archaeology and heritage;
- Define the historical aspects of each site prior to construction;
- Determine if archaeological sites exist within the treatment plant and pipeline footprints prior to construction;
- Describe the impacts of abstraction on the COH WHS; and
- Quantify the impacts of neutralised water discharge (quality and quantity) with regards to:
  - The COH WHS; and
  - Culturally significant sites downstream of the receiving streams.

Characterisation of the receiving environment

The current receiving environment (heritage landscape) will be characterised to include existing and potential heritage resources. This characterisation will be done for all three basins sites and will largely be performed prior to construction commencing. The COH WHS will be characterised independently.

In order to characterise the heritage landscape the following methods will be employed:

- Literature review and summary
  - Review of existing heritage impact assessment reports;
  - Review of relevant published and unpublished documents;
  - Archival and historical background research; and
  - Cartographic survey.

Characterising of the COH WHS

The current receiving environment of the COH WHS will be characterised based on existing information. In order to characterise the heritage landscape the following methods will be employed:

- Review of existing heritage impact assessment reports; and
- Review of relevant published and unpublished documents

Through the literature research sensitive areas in terms of heritage resources will be identified. Heritage resources identified will be evaluated to determine authenticity and integrity. Assessment criteria provided in Section 3 of the NHRA will guide this evaluation and a heritage value will be given.

In terms of the three proposed treatment plant sites, sensitive areas will be characterised in two manners:

1. Immediate receiving heritage landscape that will or may be affected by construction activities;
2. Peripheral receiving heritage landscape that may be affected during operations.

The first sensitive landscape will include footprints of all infrastructure proposed such as HDS plants, pipelines and water abstraction points. This may include tangible heritage resources such as historical structures, graves, protected areas, and more intangible aspects such as landscape character and sense of place. This will be assessed before construction commences.

The peripheral receiving environment may include more intangible heritage aspects such as baptism localities in rivers downstream from discharge points. In terms of the COH WHS, it will be described in terms of peripheral receiving environment and the gazetted boundaries used to characterise the affected area. Relevant information obtained during the Social Impact Assessment will contribute to define the scope of the heritage study.

Assessment

Impacts on heritage resources that may result from activities associated with the AMD project will be assessed. This will primarily be based on the research conducted during the characterisation of the environment. The Integration of information from other specialist studies, however, will also be used to quantify impacts.

Magnitude of the impacts will be considered relative to the value of the heritage resources.

The no-go option will also be assessed in terms of impacts on heritage resources. In addition, unknown resources that may be impacted by the construction of associated infrastructure such as pipelines will also not be affected or accidentally exposed.

9.6.2.6.4 Project team

The heritage impact assessment will be completed by Johan Nel of Digby Wells Environmental.

9.6.2.7 Ecological assessment

The ecological assessment will comprise of individual studies of response indicators for each affected system and/or area for the project. The findings from these studies will then be integrated in order to describe the current state of these systems.

9.6.2.7.1 Scoping issues

Risk No.16 determined that it is possible that the downstream ecology of the receiving streams will be impacted on due to the release of neutralised water into the respective systems. This risk was ranked as having a medium significance (13).

In addition, risk No. 22 determined that there is a low risk (6) that the hydrology of the respective systems will be altered due to the release of water into the systems. The two abovementioned risks will be considered for this specialist component.

During the scoping phase of the project a number of issues relating to ecology were received. The following key issues have been summarised:

- The impacts of the project on the aquatic ecology;
- The impact of salinity on ecology of the rivers;
- The impact on the ecology during low flow periods; and
- The impact on the Blesbokspruit as Ramsar site due to increased water volumes and decreased water qualities.

9.6.2.7.2 Potential impacts the project may have in this specialist area

A summary of the potential impacts are provided in Table 9-12 and the assessment of the significance of these potential impacts will be the focus of the fauna, flora and wetland assessment.

Table 9-12: Potential impacts on ecology

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ None
2. The construction and operation of the HDS Plants and the discharge of neutralised water in the environment	■ Construction of HDS plant may cause alteration, damage to habitats (Western Basin) ■ Potential increase in water flow due to discharge may impact on aquatic habitats of vertebrates and invertebrates ■ Potential increase in water quantity may cause inundation of riparian zones ■ The increase in salinity of the water may impact on ecological functioning of systems
3. Construction and operation of pipelines	■ Construction of pipelines may disturb or destroy natural habitats ■ Spillages of pipelines will impact on natural vegetation and animals
4. The disposal of the sludge	■ None

9.6.2.7.3 Method and objectives of the study

The ecological assessment will fulfil the following objectives:

- Defining the ecological state of the receiving systems;
- Detect and report on spatial and temporal trends in the ecological state of the ecosystems affected;
- Identifying the wetland systems within the study area;
- Assessing the impact of the increase in salinity on:
  - Invertebrates;
  - Fish;
  - Vegetation; and
  - Waterfowl.
- Assessing the impact of the increase in water flow on:
  - Aquatic habitats;

- River geomorphology and wetlands.

- Assessing the impact of the increase in water volume on:
  - The riparian zone; and
  - Wetlands.

Characterisation of the receiving environment

The aquatic, riparian and wetland habitats are well known and researched throughout the study area and using this information the current ecological status of the systems will be determined. A desktop review will be conducted for this study which will consider the available literature sources applicable to the study area. This review will establish a description for the relevant systems.

Collection of existing data for the study area will take place through various means, these include:

- Literature – existing studies and publications for the study area will be reviewed and will assist in describing the receiving environment;
- Datasets – a number of datasets are available in-house as well as through organisations. The following dataset will be used in the characterisation of the receiving environment:
  - The ecological integrity (health) database model for the systems;
  - The RHP;
  - The Freshwater Ecological Priority Areas for the catchments; ;
  - The Gauteng Conservation Plan;
  - South African National Biodiversity Institute (SANBI) data resources:
    - BGIS
    - POSA
    - Precis list
  - Protected ecosystems (SANBI);
  - Protected areas;
  - Important Bird Areas (IBA);
  - South African National Bird Atlas Project 2 (SANBAP 2);
  - Quarter degree square grid for birds;
  - 1:50 000 topographical data (delineation of wetlands);
  - Environmental Potential Atlas (ENPAT); and
  - International Union for Conservation of Nature (IUCN).

- Consultation – consultation with institutions, authorities and professional will be done to gather information for the study area. These include:
  - SANBI;
  - RHP Gauteng; and
  - CSIR.

The data collected will then be interpreted to define aspects relating to the study area. These aspects are listed below:

- Ecological importance - the following components of the systems will be assessed to determine the ecological importance:
  - Rivers/Wetlands – The ecological importance of a water resource refers to the ability to maintain ecological diversity and functioning on local and wider scales. Information pertaining to the natural and current species composition for the respective systems will be considered in order to describe the diversity of these systems. In addition to this, the tolerance of the current species will also be considered in order to describe the sensitivity of the species to changes. The functioning of the systems will primarily consider the ability of these resources to enhance water quality, regulate streamflow as well as consider human uses;
  - Cultural/Medicinal - Certain plant species identified as being present within the study areas will be of medicinal or cultural values according to National and Provincial legislation. These species play a vital role in cultural beliefs and local medicines and are harvested for their associated value. These values are well documented with existing records and studies. These will be utilised for identification;
  - Endemic - The ecological state of being unique to a defined geographic location. Flora and Fauna species identified through previous records and studies of the study areas could be classified as endemic, this status is supported by National and Provincial legislation; and
  - Red data - The review will involve the classification of species occurring within the study area that are of conservation concern and listed by the International Union for Conservation of Nature (IUCN) or by Provincial legislation as protected and endemic. Each species will be listed and the Red Data status identified and recorded. Use will be made of existing records, findings and sightings to identify keystone and indicator species within the study area.
- Ecological status - The ecological status of each system aspect will be determined. The ecological state of the wetland systems will be determined at desktop level. This will be determined by the application of the WET-Management series which will describe the general services provided by the systems. The health of the wetland systems will be determined by the collation of the available data and information.

The ecological state of the responders of the aquatic ecosystems will be determined at desktop level compared to the natural or close to natural reference conditions. The state of these responders will be considered in order to determine the ecological state of the respective systems. The ecological state derived for each of the biological response components for a particular river will be used to derive an overall, integrated ecological state.

The data collected during the characterisation of the social environment detailing the extent and nature of anthropogenic land use, such as agricultural, residential, commercial and industrial, will be compared to empirical data sets for floral communities such as Mucina's and Rutherford Vegetation types of South Africa, to detail the current extent of these vegetation types. Through this process the current status of the floral communities will be determined.

- Sensitive Areas - based on legislated protected areas and Ramsar sites as well as the Protected Ecosystems as defined in NEMA, sensitive areas will be characterised and described for the study area.

Using the information collected and the classifications of the ecological status of the systems, impacts will be determined for the project. The impacts of the water quality and increase in flow rates would be the focus in quantifying the impacts on the ecological systems.

Depending on the findings of the phase 1 assessment, it may be required to verify the findings through fieldwork and sampling.

9.6.2.8 Air quality assessment

The air quality assessment will involve a review of the existing air quality environment. This will involve the characterisation of relevant aspects using various data sources. The study will attempt to understand existing impacts from the tailings facilities which are planned to be used for sludge disposal as well as understand the sludge characteristics and its effects on the tailings material. This data will be combined with toxicity analyses and a call made as to whether this is a significant potential change to the surrounding communities or not. This will constitute Phase 1 of the project. Depending on the characterisation of the sludge, dispersion modelling may take place as phase 2 of the assessment.

9.6.2.8.1 Scoping issues

The risk assessment identified that radiation pathways were a high risk (21). The dispersion of sludge through the air is considered to be a pathway. Risk 13 raised the fact that the project could have health risks, this is related to air quality.

9.6.2.8.2 Potential impacts the project may have in this specialist area

The potential impacts are detailed in Table 9-13.

Table 9-13: Potential impacts on air quality

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ No Impact
2. The construction and operation of the HDS Plants and the discharge of neutralised water in the environment	■ Limited impact to the receiving environment during the construction phase of HDS Plants, which can be mitigated/managed by Construction EMP. ■ Impacts during the operational phase will be insignificant as projected traffic on the unpaved roads will amount to 8 (eight) trucks per day.
3. Construction and operation of pipelines	■ None
4. The disposal of the sludge	■ The possible impact to the receiving environment during the operation phase through the generation of dust from the tailings dams where the sludge will be deposited. This could lead to exposure of people to particulate matter in the form of PM10, PM2.5, dust deposition and radionuclides.

9.6.2.8.3 Method and objectives for the study

The objectives of phase one of the assessment are as follows:

- To characterise the receiving environment in terms of:
  - Climate;
  - Proximity of receptors; and
  - Spatial extent in terms of influence.
- Identify sensitive receptors;
- Assess the sludge characterisation with regard to:
  - Particle size distribution; and
  - Chemical properties.
- Identify possible impacts associated with project based on the information gathered; and
- Determine whether dispersion modelling is required for the project.

Phase 1 - Data collection and interpretation

In order to characterise the receiving environment, information on the following parameters will be acquired and assessed:

- Meteorological and climate data (rainfall, wind speed and direction, temperature, relative humidity, atmospheric stability) - South African Weather Service;
- Particle size distribution (for deposited sludge and tailings storage facilities where sludge will be deposited), as well as physical and chemical properties of deposited sludge (base metal content, water content, solids content and crusting properties);
- Sensitive receptors (communities of concern). This will be determined through the characterisation of the social environment as well as existing databases; and
- Data collection form the mines that own and operate the TSFs will also be conducted to determine what the historical impact of the facilities has been on the environment. This can only be done once agreements with the relevant mining companies have been finalised.

Phase 1 - Assessment

The assessment conducted during phase 1 will involve the identification of possible impacts based on the data gathered. The meteorological data will be used to determine predominant wind directions and speeds which will aid in identifying possible receptors. Seasonal variation will also be assessed and the associated impacts identified.

The results of the sludge characterisation will also be assessed to determine the chemical and physical nature of the sludge and whether impacts associated with the dispersion of the sludge could occur once deposited. These results will influence the need to complete phase 2 involving dispersion modelling.

Phase 2 – Dispersion modelling

Depending on the results of the sludge characterisation, dispersion modelling may be required to predict the impacts that may occur through the sludge disposal and subsequent dust generation.

Mathematical models will then be used to simulate the dispersion of air pollutants in the receiving environment. The results of the mathematical models will predict and describe the impacts on receptors through the simulation of pathways in the receiving environment. Once these impacts have been predicted and described, the significance of the impacts can be assessed. The significance of identified impacts on the receiving environment will be done by comparison of the predicted concentrations with the ambient monitoring data (if available) and NAAQS air quality standards to determine compliance with legal requirements.

9.6.2.8.4 Project Team

The project team for the study will consist of Vladimir Jovic and Mrs. Claire Wray (external review).

9.6.2.9 Agricultural assessment

Agriculture, along with its related components, may be affected by the treatment and discharge of neutralised water down the streams. It is suggested that a desktop review and interpretation of results take place to understand the possible impacts that could occur.

9.6.2.9.1 Scoping issues

The risk assessment identified a number of risks which are directly or indirectly related to agriculture. Risk 5 makes mention of radiation pathways. Build-up of uranium or radionuclides in the soil and plants (crops) may be a risk and be a pathway. Livestock may also be impacted, should they drink the water. Risk 15 saw irrigation with treated water as a potential risk. This will have an impact on agriculture.

The following issues were raised during the scoping phase:

- Impact of heavy metals on the soils;
- The costs that agriculture will bear due to the discharge of the water;
- The need for an agricultural study to be completed; and
- Impacts on agriculture due to use of the treated water.

9.6.2.9.2 Potential impacts the project may have in this specialist area

The potential impacts of the project on agriculture are listed in Table 9-14.

Table 9-14: Impacts on agriculture

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ Impact on water availability for irrigation and livestock should water levels drop
2. The construction and operation of the HDS Plants and the discharge of neutralised water in the environment 3. Irrigation of soil downstream of the treated water discharge points.	■ Irrigation water quality impacts on soil quality. ■ Soil salinity will change due to the build-up of salts contained in the treated water, in irrigated soil. ■ The presence of salt influence crop growth and therefore crop production and yields. ■ It is unclear if metals and or radionuclides will be present in the treated water but if these constituents are present than they can become bio-available entering the human and animal food chains. ■ High salinity may impact livestock drinking the

Project activity	Potential impacts
	water.
4. Construction and operation of new pipelines	■ Decreasing land capability due to smaller areas available for agriculture.
5. The disposal of the sludge	■ None

9.6.2.9.3 Method and objectives of the study

It is suggested that the characterisation of agriculture be restricted to a desktop review of existing soil types and their susceptibility to different water qualities when used for irrigation and the comparison of water qualities against guideline for livestock watering. Once the characterisation of the social environment has been completed, the water uses can be classified and it will then be determined whether impacts on agriculture will occur.

The following objectives have been set for the soil assessment:

- Classification of the soil types potentially affected by the project;
- Assessment of the water use database provided by the social assessment in terms of irrigation use;
- Define the location and extent of agricultural practices using water from the rivers or underground for irrigation and livestock drinking water;
- Determine the impact on soils based on the water quality results of the surface water study, the water use information and the soil types; and
- Determine whether the water qualities exceed the standards for livestock drinking water.

Characterisation of the receiving environment

The soil types that exist along the receiving streams will be classified according to the South African soil classification system using existing data and soil classification maps for the study area. Plans will be developed for the study area delineating the various soil types.

The data collected through the characterisation of the social environment, and specifically that data pertaining to the water use, will be interpreted to define the number of persons or organisations utilising the water for irrigation and livestock watering purposes. This will be valuable in defining the extent of use within the study area.

Impact Assessment

The water quality results and modelling data (available from the surface water assessment) will be used together with the water use and soil classification information to define and quantify the impacts that may be associated with the project.

Based on the water quality results of the surface water assessment the impact on livestock will be determined. Standards for livestock drinking water will be used to identify constituent that exceed the limits as well as to establish the extent of the possible impacts.

The impacts of the no-go option will also be assessed. The effects on livestock may be significant as the water used to supply these animals may be more saline in the case of both the no-go option as well as the discharge of neutralised AMD. Input will be obtained from the social characterisation as to who is using water directly from the streams for livestock watering, what quantities they are they using and what animals they are watering. Input will then be obtained from the water quality determinations to see to what extent this water quality will be affected. A determination will then be made of the effects of the decreased, or increased, water quality on the livestock production by comparing these qualities to the DWA Guidelines for livestock watering. Where possible existing data from research sources will be used to determine the effects on productivity.

9.6.2.9.4 <u>Project team</u>

The assessment will be undertaken by Dr Hendrik Smith of Digby Wells Environmental.

9.6.2.10 Technology evaluation

The choice of treating the water using the HDS process was seen as an initial treatment process which would limit some of the catastrophic ecological effects which could occur if the water was allowed to be discharged in an untreated fashion.

9.6.2.10.1 <u>Scoping issues</u>

During the scoping phase I&APs questioned the use of HDS as the treatment technology and asked whether other technologies could be used instead.

9.6.2.10.2 <u>Method and objectives of the study</u>

The objective of the technological assessment will be:

- To establish whether the choice of technology for the neutralisation and preliminary treatment of acid mine drainage is logical and defendable;
- To assess what other alternatives there could be and whether these alternatives should be applied to achieve the desired objective; and
- To recommend what improvements to the process design could be implemented given the project timelines and proposed longer term treatment options to be considered.

The report will contain a summary of the findings in such a manner that it can be used for public dissemination of the information and so that this summary can be readily understood by members of the public.

9.6.2.11 Economic analysis

The proposed discharge of neutralised water will increase the salinity of the receiving streams and may impose significant costs on urban and industrial and irrigation users. Based on escalated data from earlier studies, urban and industrial users incur a cost of about 0.5 c/kl per 1 mg/l increase in supply water TDS. Although this seems small, it is very significant for polluted waters with a large number of users where the increase in TDS is much greater than 1 mg/l.

9.6.2.11.1 Scoping issues

The risk assessment recognised the potential risk in the failure to identify the consequences of changes in quality as well as the risk to downstream users in terms of cost. These were ranked as 14 and 12 respectively.

The following issues were raised during the scoping phase:

- Impact on agricultural users downstream; and
- Effect of water quality on downstream users.

9.6.2.11.2 Potential impacts the project may have in this specialist area

The potential economic impacts are listed in Table 9-15.

Table 9-15: Economic impacts

Project activity	Potential impacts
1. Abstraction of water from the shafts and reaching or keeping the ECL	■ None
2. The construction and operation of the HDS Plants and the discharge of partially treated water in the environment	■ Impact on agricultural users, through irrigation or livestock users. ■ Increase in treatment costs for municipalities. Impact on pumps and equipment for downstream users.
3. Construction and operation of pipelines	■ None
4. The disposal of the sludge	■ None

9.6.2.11.3 Method and objectives of the study

Using the data gathered and determined by the surface water assessment the salinity figures will be used to determine the likely cost increases due to the discharge of neutralised water. Salinity cost factors for urban and industrial and irrigation use will be derived from existing models for different areas and use sectors.

9.6.2.11.4 Project team

The economic analysis will be completed by Dr. Chris Herold.

10 CONCLUSION AND RECOMMENDATIONS

10.1 The need for the project has been firmly established

AMD has been decanting from the Western Basin for a few years and will decant in an uncontrolled fashion from the Central and Eastern Basins unless a management system is put in place to prevent this from occurring. The disastrous ecological impacts of the untreated water being discharged in the West have been well documented and publicised. This and the imminent threat of rising water levels in the other basins has led to the government response of instructing TCTA to implement the Short Term interventions which involve:

- The achieving and maintaining of water in the old mine workings at a level where they should not affect surrounding aquifers, buildings or other infrastructure;
- Construction and operation of neutralisation and aeration treatment plants; and
- Discharge of the water and the safe disposal of the brine.

If this project were not implemented the status quo would be maintained in the Western Basin and decant would occur in the Central Basin somewhere near to the Elsburgspruit, probably through some of the old mine shafts and in the Eastern Basin, decant would occur somewhere near some of the old Nigel Shafts. This decant could affect some buildings in Nigel. Both the Central and Eastern Basin decants could affect large portions of the waterways below these points and large parts of the Vaal River System. In the west the Crocodile River System from the Tweelopiespruit downstream and including the Hartbeespoort Dam would be affected. This water could affect the dolomites associated with the Cradle of Humankind and a World Heritage Site.

10.2 What are the impacts of the proposed project?

The proposed interventions will assist in managing the AMD problem in a controlled fashion and return the water systems roughly to what they were during the period when the mines were operating and pumping, treating and discharging water. The water to be discharged, however, will affect the Tweelopiespruit in the west all the way to at least the Hartbeespoort Dam and the Klip River System at least to the Vaal Barrage and possibly beyond in terms of quality land flow. As large populations draw their water from these waterways and large ecosystems are dependent on these water ways it is essential that we understand the implications of the proposed actions and where necessary change them to avoid undesirable consequences. These impacts will be compared to the option of what would be the impacts if these measures were not implemented.

There are also potential impacts associated with the disposal of the sludge on existing TSFs, with air quality and groundwater being most affected.

We currently do not know enough about the potential impacts of the project but the completion of the planned Public Participation Process and the planned studies will assist all parties in better understanding the system.

10.3 Aspects to be covered in the EIA phase

Aspects which need to be studied and are planned for the EIA phase of the project are:

- Ecological impacts – including aquatic life, wetlands and flora and fauna;
- Social issues – to address impact of the project on people;
- Human health – to understand health impacts of the project;
- Radiation aspects – to understand the impacts of radiological issues resulting from the project;
- Water quality and quantity impacts – including chemical quality, water supply, groundwater impacts and implications for flow regimes;
- Heritage and archaeological impacts – including possible impact on the Cradle of Humankind World Heritage Site and buildings and equipment which may be affected;
- Air quality impacts – as a result of sludge disposal on the tailings dams; and
- Soil impacts – due to changes in water chemistry in irrigation water.

Studying these issues will assist us in advising TCTA of any changes required to the project and also provide the authorities with data to assist them in managing the resources of the country in terms of their legal obligations.

10.4 Is this project enough?

The proposed project will still have a major impact on river systems if the water is to be released and the water is not used by any large scale user in its current form. Further treatment and management of the water is subject to a separate project which does not form part of this study.

The proposed project does however provide any future water treatment option with the first and probably the cheapest first phase water preparation and treatment option.

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Appendix A: Plans

Plan 1: Regional Setting of the proposed AMD Project

Plan 2: Local Setting

Plan 3: Immediate Intervention – Site Layout (Western Basin)

Plan 4: Western Basin Site Layout

Plan 5: Central Basin Site Layout

Plan 6: Eastern Basin Site Layout

Plan 7: Rivers and Catchments Potentially Affected by the Project

Plan 8: Western Basin Discharge Point

Plan 9: Central Basin Discharge Point

Plan 10: Eastern Basin Discharge Point

Plan 11: TSF Location for Sludge Storage – Western Basin

Plan 12: TSF Location for Sludge Storage – Central and Eastern Basins

Plan 13: Wards Possibly Affected by the Project – Western Basin

Plan 14: Wards Possibly Affected by the Project – Central Basin

Plan 15: Wards Possibly Affected by the Project – Eastern Basin

Plan 16: Location of COH WHS

Plan 17: Gauteng C-Plan and Affected Rivers

Plan 18: Witwatersrand Geology

Plan 19: Western Basin Geology

Plan 20: Central Basin Geology

Plan 21: Eastern Basin Geology

Plan 22: Crocodile West Catchment

Plan 23: Upper Vaal Catchment

Appendix B: Directives issued to TCTA by DWA

Appendix C: Company Profile - Digby Wells Environmental

Appendix D: CVs - Protect Team

Appendix E: Technology Alternatives Considered by the Team of Experts

Appendix F: I&AP Database

Appendix G: EIA Application Form

Appendix H: Letter Informing Directly Affected Land Owners

Appendix I: PPP Information Documentation

Appendix J: Proof of Newspaper Adverts

Appendix K: Proof of Site Notices

Appendix L: Comments and Response Report

Appendix M: Risk Assessment Summary

Appendix N: Impact Map – Operational Phase