KUSILE 60-YEAR ASH DISPOSAL FACILITY

SUSTAINABILITY ASSESSMENT FOR KUSILE POWER STATION 60-YEAR ASH DISPOSAL FACILITY

SECOND DRAFT REPORT FOR REVIEW

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Prepared for

ZITHOLELE CONSULTING

Prepared by

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EXECUTIVE SUMMARY

Eskom's Kusile Power Station requires an Ash Disposal Facility (ADF) site upon which to store ash produced during the coal-firing process for a period of 60 years. The Kusile Power Station will not be able to operate without this disposal site. As part of the Environmental Impact Assessment (EIA) process, six Alternatives for the ADF were developed. These Alternatives are as follows:

1. Alternative 1 (Area A)
2. Alternative 2 (Area B)
3. Alternative 3 (Area C)
4. Alternative 4 (Area G & reduced A)
5. Alternative 5 (Area F & reduced A).
6. Alternative 6 (Area F & G).

Each of these Alternatives is associated with a variety of costs and benefits resulting from social, ecosystem and financial impacts.

This report provides an overview of the ecological and socio-economic systems within which the ADF sites are located. It then presents the results of a multi-criteria analysis (MCA) performed by the study specialists to select the most preferred site. Each of the 13 specialists adjudged the site alternatives based on different criteria that are specific to their field of study. This could result in a Alternative where each specialist proposes a different preferred alternative and consensus around a single preferred development alternative may not be possible. Prime Africa Consultants was therefore tasked with conducting the Sustainability Assessment for the selection of a preferred alternative. The analysis conducted here builds on specialist studies performed by 13 specialists. The specialists included in the study are given below.

1. Wetlands;
2. Aquatic Biodiversity;
3. Surface Hydrology;
4. Groundwater;
5. Terrestrial Ecology;
6. Avifauna;
7. Bats;
8. Social;
9. Heritage;
10. Soils;
11. Air Quality;
12. Geotechnical/Engineering; and
13. Traffic.

The individual specialist studies are available from Zitholele Consulting.

Once the specialist reports were evaluated the study team applied a cost-benefit analysis (CBA) to conduct a comparative analysis of the six Alternatives. The CBA analyses the financial costs of each of the sites and converts the specialist findings into an economic analysis by adopting an ecosystem services approach.

The initial results indicated that Alternative A was the preferred site overall. After correspondence was received from the Department of Water Affairs (DWA) on the 28th June 2013, it was decided that the specialists should further analyse the merits of Alternative B, as this was considered the preferred site by DWA. The reanalysis of Site B by the specialists was conducted over four months and Alternative A was again selected as the preferred site.

The key benefits of Alternative A include:

- Lowest inferred ecosystem cost (i.e. most preferred) alternative by the aquatic specialists (Wetlands, Aquatic Biodiversity; Groundwater) – it is therefore the site with the lowest environmental impact;
- Lowest social cost – this site is preferred by the social impact assessment specialist and is therefore the site that has the lowest social impact;
- Largest mitigation potential – As the site is closest to the existing power block as well as directly adjacent to the proposed New Largo Colliery; mitigation options can be combined to provide a focussed mitigation strategy for the entire project footprint. This is therefore the site which holds the most potential for minimising and offsetting of environmental impacts;
- Least number of dirty water dam controls (one only on the Klipfonteinspruit, more than 6.5 km from the Wilge River) - this limits the risk of water pollution and maximises the ability to mitigate impacts on the Wilge River;
- Lowest cost Alternative to Eskom – this therefore also translates into the lowest cost Alternative to electricity users.

Alternative A has several negative impacts, which need to be addressed in a mitigation strategy. This includes 227 ha of wetland area and associated terrestrial habitat that would be lost as well as graves that need to be relocated. The possible (and preliminary) mitigation actions would provide a mitigation strategy that would include aspects of the terrestrial, aquatic and heritage components that contribute to the socio-ecological system of the study site.

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ACRONYMS

ADF	Ash Disposal Facility
CBA	Cost Benefit Analysis
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
ENPV	Economic Net Present Value
ERE	Environmental and Resource Economic
FNPV	Financial Net Present Value
GDP	Gross Domestic Product
MEA	Millennium Ecosystem Assessment
MCA	Multi Criteria Analysis
NFEPA	National Freshwater Ecosystem Priority Areas
RQO	Resource Quality Objective
SANBI	South African National Biodiversity Institute
TEEB	The Economics of Ecosystems and Biodiversity
WACC	Working Average Cost of Capital
WMA	Water Management Area
WRCS	Water Resources Classification System

1 INTRODUCTION

1.1 Overview

The Kusile Power Station (hereinafter referred to as Kusile) has been under construction since April 2008 and is expected to be completed in 2018. The station will consist of six units each rated at approximately 800MW producing a total installed capacity of 4800MW. In terms of scale, Kusile will be the fourth largest coal fired power station in the world. The size and location of Kusile has meant that there have been significant impacts on the surrounding terrestrial and aquatic environments and the local economy.

Kusile requires an Ash Disposal Facility (ADF) site upon which to dispose ash produced during the coal-firing process for a period of 60 years. Kusile will not be able to operate without this disposal site. As part of the Environmental Impact Assessment (EIA) process, six alternatives for the ADF were developed. These scenarios are as follows:

1. Alternative A (Area A)
2. Alternative B (Area B)
3. Alternative C (Area C)
4. Alternative GA (Area G & reduced A)
5. Alternative FA (Area F and reduced A).
6. Alternative FG (Area F & G).

Each of the scenarios has their own associated environmental, social and economic costs and benefits, which have been analysed in this report.

1.2 Purpose and Structure of the Report

Prime Africa Consultants has been tasked with conducting the Sustainability Assessment for the Kusile Power Station Ash Disposal Facility. Throughout the project, the project team has consulted with the Department of Environmental Affairs (DEA) and the Department of Water Affairs (DWA) in order to provide the best possible solution in selecting the preferred alternative.

In particular, consultation was held with DWA on the 10th April 2013, where the project team (including the various specialists) provided the evidence for the selection of Site A as an alternative. In response, correspondence was received from the Department on the 28 June 2013, which clarified their position of Site B as their preferred alternative. A further meeting was held with the DWA on the 14th August 2014, where the Department requested more information on the environmental impacts associated with Site B in particular. Taking the request into consideration, the 13 specialists were tasked with re-evaluating their impact assessments to include a more detailed assessment of Site B in terms of regional impacts and possible impacts on surface water resources within the affected quaternary catchments. The reassessment of Site B by the specialists took an additional four months and was completed by November 2013. Therefore this second draft of the Sustainability Assessment takes cognisance of the expanded assessments of the specialists and provides an expanded socio-economic cost benefit analysis of the preferred alternative.

The draft report is divided into the following sections:

1. Section 2. Systems description of the study area in terms of environmental, social and economic features;
2. Section 3. Summarises the opinions of the specialists on the preferred alternative;
3. Section 4. Presents the social-economic cost-benefit analysis;
4. Section 5. Prioritises sites based on inputs received from the other specialist studies; and
5. Section 6. Recommendations and discussion around practical mitigation measures.

2 SYSTEMS DESCRIPTION

The purpose of the Systems Description is to give an overview of the environmental, physical and socio-economic conditions, which are present in the study area. These conditions play an important role in the selection of the site alternative for the 60 Year Ash Disposal Facility.

2.1 Description of Alternatives

Eskom's Kusile Power Station requires an Ash Disposal Facility (ADF) site upon which to dispose ash produced during the coal-firing process for a period of 60 years. The Kusile Power Station will not be able to operate without this disposal site. As part of the Environmental Impacts Assessment process, six alternatives for the ADF were developed. These alternatives are as follows:

1. Alternative A (Area A)
2. Alternative B (Area B)
3. Alternative C (Area C)
4. Alternative GA (Area G & reduced A)
5. Alternative FA (Area F & reduced A)
6. Alternative FG (Area F & G).

The locations of these areas are set out in the figure below.

Each Alternative connects to the Kusile Power Station through a conveyor route (indicated by a dotted line in the figure below). Each of the Alternatives also requires the construction of dirty water dams (indicated by orange squares in the figure below). The construction and operation of a typical ADF is described in a specialist studies by Jones and Wagener Consulting Engineers.

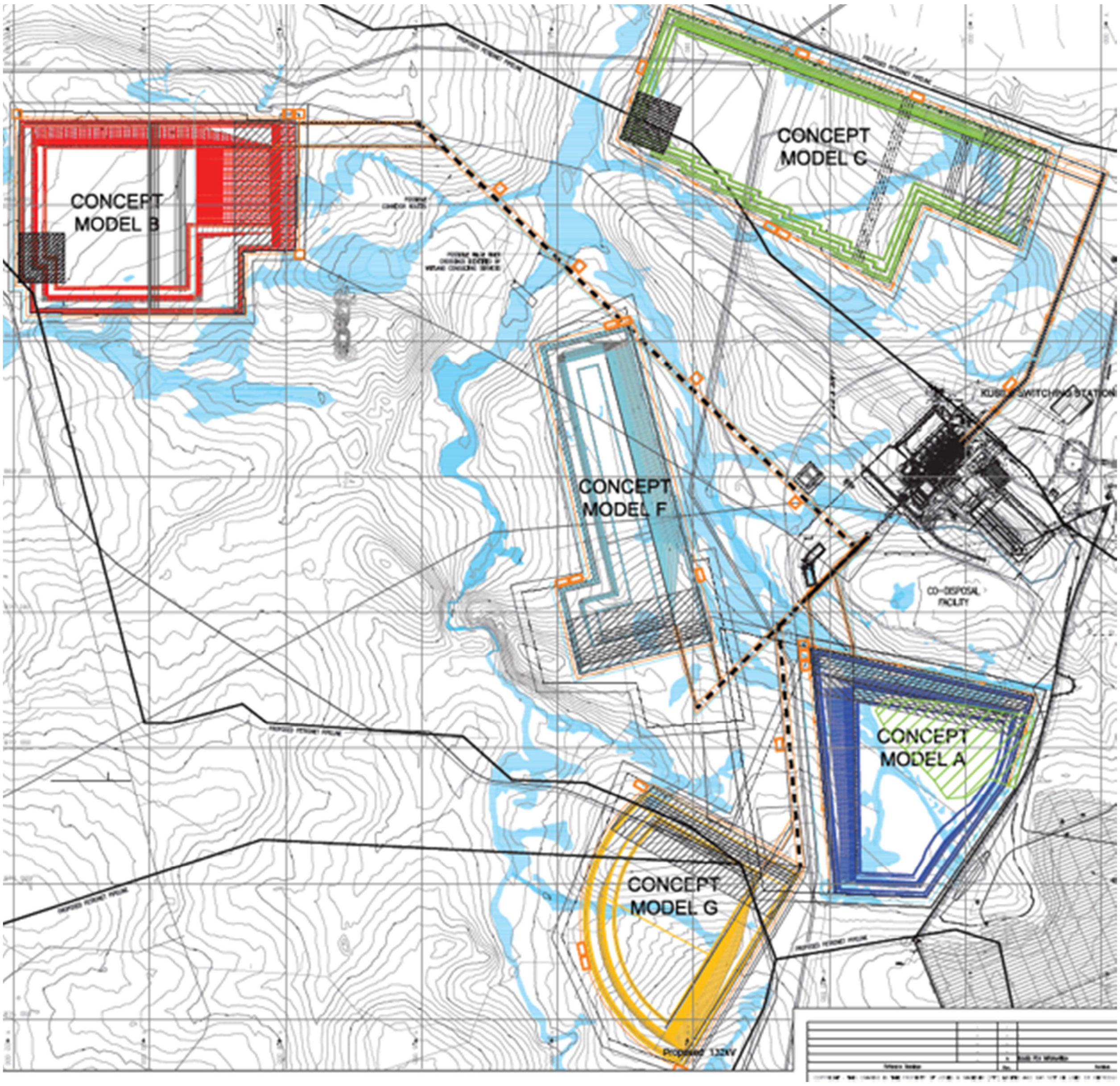

Figure 2-1. Conceptual design layouts of Areas A-G that comprise the six alternatives evaluated in this report

2.2 Environmental & Socio-Economic Attributes

A detailed description of the environmental and socio-economic attributes is given in Appendix 1: Systems Description.

2.3 Strategic Importance of the Wilge River

Wetland habitat in the Wilge catchment (a tributary of the Olifants River) is important because it is a component of the ecological infrastructure comprising the aquatic ecosystem of the Olifants River Catchment. DWA (2012) estimated that the value of aquatic ecosystem services (within which wetland ecological infrastructure plays an important role) was approximately R3 billion per year. Moreover, more than 55% of the GDP contributing sectors in the Olifants River Catchment are directly dependent on water use licences. The economy and people of the Olifants River Catchment are thus highly dependent upon the water resources of the catchment.

At the time of writing DWA was in the process of completing the classification of the Olifants River Water Management Area (WMA) and initiating the Resource Quality Objectives (RQO) process. The water resource classification system (WRCS) defines management classes and RQO's for the water resources in the WMA, with the purpose of maintaining ecological sustainability of the whole Olifants catchment.

It seems likely at this stage that the WRCS would classify the Wilge River Catchment as a Class II river. A Class II river is defined by legislation as one which is moderately used and of which the overall ecological condition of that water resource is moderately altered from its predevelopment condition. By comparison, a Class III river is heavily used and the overall ecological condition of that water resource is significantly altered from its predevelopment condition. Class III represents the maximum allowable impact that can be made to river systems. To give context to what Class II and Class III river systems look like, the river and wetland systems of the neighboring eMalahleni catchment area, which is characterised by extensive coal mining and power generation activities, is regarded by DWA as in an unacceptable condition. By implication, the eMalahleni catchment area needs to be significantly remedied to be classed into a Class III system.

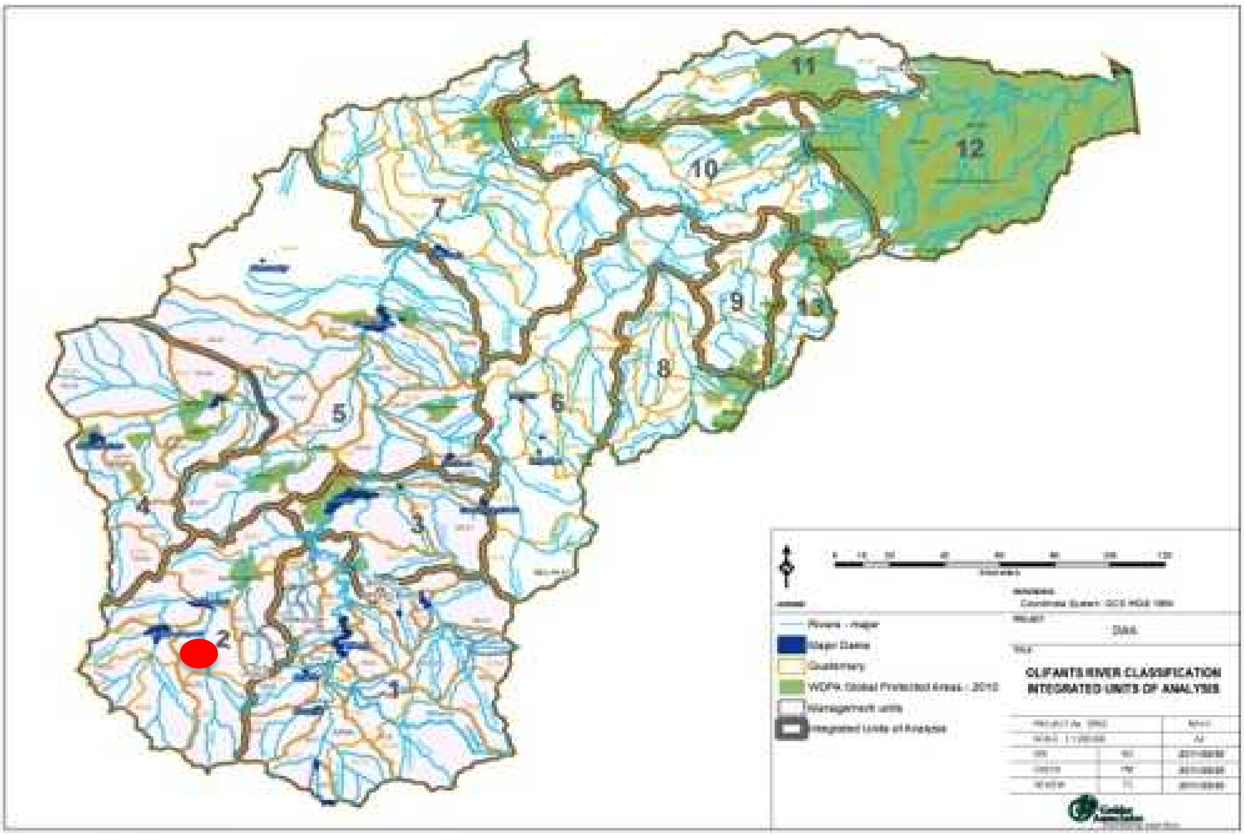

Figure 2-2. Map showing the Olifants Water Management Area (WMA). The approximate position of the Kusile Power Station and the Wilge River are indicated by the red dot in the Upper Olifants sub-catchment

The river health standard associated with a Class II includes water flow, water quality, geomorphology and fauna and flora indicators. The overall standard of the Wilge River Catchment is represented by a monitoring site (labelled by DWA as EWR 4, hydro-node HN31), situated at the outflow of the Wilge River in quaternary catchment B20J downstream of the Kusile project area. The quaternary catchment B20F, in which the Kusile project area falls, is represented by hydro-node HN27, situated at the confluence of the Wilge River and the Bronkhorstspruit. Both EWR 4 and HN27 are categorised as high to very high ecologically importance areas, important for the biological functioning (DWA, 2011a; DWA, 2011b).

In order to achieve the anticipated river management class requirements that the WRCS process is expected to set for the Wilge River, DWA is likely to set conditions to water use licences that limits water use (as defined by the National Water Act) to that of a Class II river. These conditions would seek to limit further water abstraction, water pollution and losses to aquatic biodiversity.

2.4 Resource Quality Objectives

The Department of Water Affairs (DWA) is currently implementing the resource quality objectives (RQO) for the Olifants WMA. The purpose of the RQOs is to set the standard for sustainable water quality guidelines dependent on the requirements of the water users within a delineated area. At present the RQOs for the Olifants WMA are in draft format and are descriptive in nature as numerical thresholds are still being developed. The RQO that relates to the B20F quaternary catchment are given in the Table below and would correspond to the conditions that would be required for a Class II river system.

Table 2-1. Narrative description of Resource Quality Objectives (RQO) for the B20F quaternary catchment

Response	Narrative Description
Quantity:	*Low flows*: Low flows and in particular the timing of such low flows, are necessary to maintain the ecosystem and to meet basic human needs, but this is being negatively impacted by upstream agriculture, urban developments and informal settlements. In order to achieve this, the low flows need to be improved to a *D category* in accordance with the Reserve determination. *High flows*: High flows should also be ensured in the river as they ensure better ecosystem maintenance and will also replenish natural storage systems in the river, but this is being negatively impacted by upstream agriculture, urban developments and informal settlements. High flows should be provided in accordance with the Reserve recommendations and the category should be improved to *D category*.
Quality:	*Pathogens*: The large numbers of un-served upstream communities are producing waste which is entering the river resource and is contaminating water resources being used by downstream communities. Concentrations of pathogens should be maintained at levels where downstream use is not compromised. A *C/D category* is necessary for this.
Habitat:	*Instream*: The instream habitat of this river is important for sustainable use of the river but is being negatively impacted by reduced flows from upstream as well as reduced water quality. This will require rehabilitation of the instream habitat to a level where the instream ecosystem processes can support the associated ecosystem. This should be improved to a *D category*.
Biota:	*Fish*: Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use. The fish condition should be improved to a *D category.* *Aquatic invertebrates*: Invertebrates provide an important part of the overall river ecosystem and when in good condition will support the fish populations. They also provide a useful

	indicator of the health of the overall ecosystem and also suitability of some users. The invertebrates should thus be improved to a *D category* where they indicate a sustainable river ecosystem.

3 SITE PRIORITISATION – MULTI-CRITERIA ANALYSIS

3.1 Multi-criteria analysis

The goal of the Multi-Criteria Assessment (MCA) is to select the best possible site for the Kusile ADF using the specialist's inputs and reports. The MCA method used for the site selection for the Kusile ADF is a variation on the Analytic Hierarchy Process. The Analytic Hierarchy Process consists of pair wise comparisons and fractions in the scoring and weighting (Saaty, 2008).

The scoring and weighting in the MCA for the 60-year ADF are individually scored and weighed with single numbers within certain criteria levels. Different scales are used for the scoring and the weights.

3.1.1 Overview of MCA Methodology

The following section gives an overview of the methodology used in the MCA.

Each of the 13 specialist reports are assigned a Level 1 Criteria i.e. Engineering, Wetlands, Social etc. Each specialist report is then scrutinised from which the major concerns are used to inform the Level 2 Criteria (Table 3-1).

Table 3-1. List of Level 1 and 2 Criteria for the MCA. Note only three specialist studies are used in the example below

Criteria 1	Criteria 2
Engineering	Distance to Power Station (Conveyor routes)
	Topography
	Storage & Expansion potential
	Land ownership
	Accessibility
	Capacity of site
	Storage Efficiency
	Drainage direction
	Slope
	Geotechnical
	Cost
	Direction to Powerstation (wind)
	Diversion of natural or major infrastructure
	Operability
	Rehabilitation
Wetlands	Wetland extent impacted
	Present Ecological Status
	Ecological Importance and Sensitivity & Red Data Species
	Functional Assessment
	Proximity to the Wilge River
	Service Corridor
	Mitigation/offset Potential
	Location within already impacted catchment

Aquatic	Fish Assemblage Integrity Index
	Aquatic invertebrates
	Water quality
	Habitat integrity
	Conveyor crossing

The specialists were then asked to score each of the six alternate Alternatives in terms of the Level 2 Criteria applicable to their study and assign a weight to the overall importance of each criterion. The overall score from each of the Alternatives for each of specialist studies is then ranked from the highest score, as the best preferred to the lowest which is the least preferred.

3.1.2 The Scoring and Weighting Scales

A 7-point scale is used for the scoring of the criteria (Table 3-2) and a 5-point scale (Table 3-3) is used for the assigning of weights.

Table 3-2. The seven point scoring scale

Scoring Scale	
1	Unacceptable
2	Bad site
3	Tolerable
4	Not sure
5	Acceptable
6	Good Site
7	Ideal

Table 3-3. The five point weighting scale

Weighting	Description
1	Nice to have
2	Significant
3	Important
4	Very Important
5	Technical Priorities

3.2 MCA Results: The Preferred Site According to Specialists

The final rankings are given in Table 3-4 below. The rankings were determined by the methodology described above, which included in-depth discussions which each of the specialists. The analysis shows that Alternative A is the preferred site, while Alternative FG is least preferred. Alternative C is second most preferred, however due to social concerns Alternative C, is not likely to be chosen. Alternatives B, GA and FA are evenly scored at the third most preferred sites. It is important to note that this table is based on the specialist's response to the MCA questionnaire that was sent out in March 2013.

The sections below present a more detailed discussion by specialist area.

Table 3-4. Final ranking of site alternatives for the 60 Year Ash Disposal Facility, based on the MCA performed by the EIA specialists during March 2013. (Table 4.1 below provides a revised assessment, based on the additional specialist work, per DWA request)

Criteria	**Alternative A**	**Alternative B**	**Alternative C**	**Alternative GA**	**Alternative FA**	**Alternative FG**
Wetlands	1	3	6	2	4	5
Aquatic	1	2	3	4	6	5
Groundwater	1	n.a.	n.a.	n.a.	n.a.	n.a.
Terrestrial Ecology	6	5	4	1	2	2
Avifauna	2	6	1	5	2	2
Bats	6	5	1	2	2	2
Air Impacts	3	1	2	4	5	5
Soil	1	6	2	3	5	3
Social	1	2	6	2	4	5
Heritage	3	4	2	5	1	5
Traffic	1	5	5	2	2	2
Engineering	1	2	4	2	5	5
Number of specialists who most preferred the site	**7**	**1**	**2**	**1**	**1**	**0**

4 REVIEW OF SPECIALIST REPORTS

In addition to the MCA, each of the specialist reports were reviewed and analysed once the additional analysis requested by DWA was completed at the end of November 2013. The results of the specialist reports are given in Table 4-1 below. Alternative A remains the preferred site.

Table 4-1. Specialist ranking for each of the six alternatives, after performing additional work during the period April – November 2013

Criteria	**Alternative A**	**Alternative B**	**Alternative C**	**Alternative GA**	**Alternative FA**	**Alternative FG**
Wetlands	1	3	6	2	4	5
Aquatic	1	4	2	3	5	6
Groundwater	1	4	6	3	2	5
Surface Hydrology	2	2	1	4	4	4
Terrestrial Ecology	5	6	4	1	2	2
Avifauna	2	1	6	3	4	5
Bats	1	3	4	2	5	6
Air Impacts	1	2	2	-	-	-
Soil	4	5	1	2	3	6
Social	1	5	6	4	2	3
Heritage	3	4	2	5	1	5
Traffic	1	5	5	2	2	2
Engineering	1	2	4	2	5	5
Number of specialists who most preferred the site	**8**	**1**	**2**	**1**	**1**	**0**

4.1 Wetlands

4.1.1 Assessment

Wetland Consulting Services (WCS) assessed the suitability of the site alternatives from a wetland impact perspective. Alternative A was adjudged the preferred alternative, followed by Alternative GA, B, FA, FG and then C.

The rationale for selecting Alternative A as the preferred site, is given below:

1. Highest extent of wetlands within footprint, BUT low extent of wetlands immediately adjacent to the ADF footprint;
2. Located furthest from the Wilge River, with 7 km distance to act as buffer to the Wilge River;
3. Located within the same sub-catchment as Kusile Power Station and the Co-Disposal Facility; and
4. Located within a sub-catchment that will be substantially impacted by mining (18% of catchment).

From a wetland perspective, Alternative B presents a number of concerns:

1. Its location along a watershed implies that 4 sub-catchments currently unaffected by mining or Kusile Power Station activities will be impacted. This will significantly increase the impacted area and zone of influence.
2. Water drains from the site in four different directions, complicating water management and increasing the risk to wetlands.
3. The four impacted sub-catchments, as well as the long conveyor route result in pollution control dams being required in at least 7 localities.
4. The conveyor will be required to cross the Wilge River, the highest priority water resource of the area, exposing it to risk of contamination. The required crossing will likely be more than 50m wide given the need for 2 conveyors, access roads, powerlines etc.

When comparing the site alternatives and their respective impacts on wetlands, the following criteria were considered:

- ***Wetland extent directly impacted*** – all wetlands falling within the footprint of the proposed ADF will be permanently lost, as will the functions and biodiversity supported by those wetlands.
- ***Wetland extent indirectly impacted*** – impacts associated with the development will not be restricted to the development footprint, but will affect adjacent wetlands, specifically those located downslope of the development.
- ***Present Ecological Status*** – the more degraded a wetland system, the less likely that such a system can be rehabilitated and the less likely it is that the wetland can still successfully perform a range of functions. It is therefore considered preferable to locate the proposed ADF on wetlands already degraded than on natural wetlands.
- ***Ecological importance and sensitivity & Red Data species*** – as indicated, all wetlands within the footprint of the ADF will be lost. Biodiversity associated with these wetlands will also be lost or displaced. Priority is placed on those wetland habitats known to support Red Data species.
- ***Proximity to the Wilge River*** – the Wilge River is considered the highest priority water resource within the affected area, and preventing water quality deterioration within the Wilge should be one of the top priorities. The greater the distance between the pollution source and the Wilge, the greater the opportunities to implement mitigation measures and contain contaminants. In addition, any wetland habitat between the ADF and the Wilge River could potentially act as a buffer to the Wilge River in terms of water quality deterioration through trapping and assimilating some of the pollutant load.
- ***Impact on affected/unimpacted wetlands*** - it is considered preferable to place the ADF within sub-catchments that have already been impacted by other activities within the area rather than in unimpacted sub-catchments, and thus spreading the impact footprint. Other activities occurring in the area and affecting the wetlands that have been considered include the Kusile Power Station, the Co-disposal Facility and the adjacent New Largo opencast mining, which is yet to commence. Sub-catchments affected by these activities will already require extensive interventions in terms of water quality and wetland management.
- ***Cumulative impact of other activities in the area*** – a number of developments are taking place within the vicinity of the proposed ADF location, including the Kusile Power Station, the Co-disposal Facility and the New Largo mining developments. These activities will also

impact on the wetlands of the area and will need to be considered when deciding which wetlands should be excluded from the ADF footprint.

- ***Service corridor*** – each of the proposed alternatives will require a service corridor constituting a servitude roughly 135 m wide and including conveyors, powerlines, pipelines, service roads etc. Each of these service corridors will be of different length and will be required to cross various wetlands. The service corridor is likely to increase the pollution footprint of the proposed development and have a significant impact on habitat fragmentation.

4.1.2 Ecosystem Services at Risk

The loss of wetland area will result in the loss of ecosystem services delivered to downstream users. Wetlands are known to play an important functional role in water purification, water regulation, carbon sequestration (in the case of peat bogs) and the delivery of several provisioning and cultural services.

In the case of Alternative A and the subsequent loss of wetland area it is likely that the following ecosystem services will be compromised:

- Water purification; and
- Water regulation
- Habitat.

It is unlikely that local communities are dependent on the impacted wetlands for the supply of provisioning services i.e. food, raw materials and fresh water or any of the cultural services.

4.2 Aquatic Ecosystems

Site A is considered the preferred site by the Aquatic Specialist (Wetland Consulting Services) due to the potential of the buffering capacity of the Klipfonteinspruit against impacts being transferred to the Wilge River.

The specialist ranked the site alternatives as follows (most preferred to least preferred): Alternative A, Alternative C, Alternative GA, Alternative B, Alternative FA and Alternative FG.

Alternative B was not considered as a preferred site mainly due to the impact of the conveyor and associated infrastructure on the two quaternary catchments and four sub-catchments within the study area. The conveyor will cross three river systems at four crossings, including the Klipfonteinspruit, Wilge River and Wilge tributary. The conveyor is likely to impact upon diversity and the prevalence of sensitive taxa within the Wilge River. The magnitude of these impacts cannot be accurately assessed but potentially severe with mitigation difficult.

4.2.1 Environmental Description

The purpose of the Aquatic Ecosystems component was to conduct a baseline ecological assessment of aquatic ecosystems associated with each alternative based on:

- Aquatic macro invertebrates;

- Fish;
- Diatoms;
- Water quality; and
- Habitat integrity.

The major impacts associated with the alternative sites that are likely to be experienced include the following:

- Loss of aquatic habitats through direct wetland destruction;
- Loss of habitats and wetland/riparian buffer zones through erosion;
- Loss of habitats and buffer zones through sedimentation (altered substrates and vegetation);
- Contamination of surface water – contaminated surface runoff (containing sediments, contaminants), together with wind-blown contaminants and leaching via groundwater;
- Turbidity – deterioration in water quality will affect aquatic species; and
- Overall decline in aquatic biodiversity because of all of the above.

Taking these impacts into consideration and the fact that the Wilge River is considered an important and sensitive ecosystem, supporting a range of sensitive fish and invertebrates, Alternatives A and C were considered the preferred sites. While aquatic habitats and biota within Alternative A were considered to be largely intact, the Klipfonteinspruit downstream of Area A has been seriously impacted by the high volumes and velocities of runoff from developments within the catchment, including the Kusile construction site. The favourable rating of Alternative A is based on the observation that the Klipfonteinspruit system currently provides a buffering function against impacts being transferred to the Wilge River.

Alternative B was not considered as a preferred site mainly due to the impact of the conveyor and associated infrastructure on the two quaternary catchments and four sub-catchments within the study area. The conveyor will cross three river systems at four crossings, including the Klipfonteinspruit, Wilge River and Wilge tributary. The conveyor is likely to impact upon diversity and the prevalence of sensitive taxa within the Wilge River. The magnitude of these impacts cannot be accurately assessed but potentially severe with mitigation difficult.

4.2.2 Ecosystem Services at Risk

The results of the Aquatic Ecosystem Assessment show that the Wilge River system is an important and sensitive ecosystem and needs to be protected. The presence of the *Chiloglanis pretoriae* in the Wilge River is of significance as it is an indicator of good water quality and habitat integrity. It is thought that the *C. pretoriae* fish population in the Wilge River represents one of the few remaining populations in the upper Olifants River catchment.

While Alternative A is considered the preferred site due to the potential of the buffering capacity of the Klipfonteinspruit, it is important to note that if it is not rehabilitated and managed, there will still likely be an impact on the delivery of ecosystem services. In particular the habitat for species ecosystem service delivered by the Wilge River would be at risk.

4.3 Groundwater Assessment

The specialist adjudged Alternative A to be the preferred site. Based on the geohydrological sensitivity ranking, Alternative A appears to be the alternative that will be less sensitive in terms of the groundwater flow regime and quality depletion. Under the same criteria, Site AF is the next preferred site, while Site B is the fourth preferred site.

A significant issue with Alternative B is that if there was a groundwater pollution event it would be split between two quaternary catchments i.e. the Wilge River in B20F and the Bronkhorstspruit in B20D. Mitigation of such a pollution event would thus be harder to manage and implement.

4.3.1 Environmental Description

The purpose of the groundwater study is to assess the impact of the ADF on groundwater resources (Aqua Earth Consulting 2013). The selection of a preferred site in terms of impacts on local groundwater resources was assessed in terms of the following criteria:

- Underlying geology;
  - Top lithology to water strike;
  - Contact zones; and
  - Linear structures;
- Depth to water level;
- Aquifer characteristics;
- Recharge potential; and
- Surface water;
  - Distance from Wilge River; and
  - Number of intersected rivers.

Table 4-2. Geohydrological sensitivity criteria used to rate the alternatives for groundwater characteristics

Geohydrological Sensitivity Criteria		Alternatives					
Criteria	**Criteria Detail**	**A**	**B**	**C**	**AF**	**AG**	**FG**
Geology	Top lithology to water strike	5	1	2	4	4.5	3.5
	Contact zones	2	3	2	3.5	3	4.5
	Linear structures	2	2	5	2	2	2
	Combined geology	3	2	3	3.165	3.165	3.33
Depths to water level	--	2	5	3	1.5	3	2.5
Aquifers characteristics	--	2	2	4	3.5	2.5	4
Recharge potential	--	2	5	5	2.5	1.5	2
Surface water	Distance from Wilge River	2	1	4	3	3.5	4.5
	Number of intersected rivers	5	1	3	3	5	3
	Combined surface water	3.5	1	3.5	3	4.25	3.75
Combined rating	--	12.5	15	18.5	13.665	14.415	15.58
Ranking	--	**1**	**4**	**6**	**2**	**3**	**5**

4.3.2 Impact of New Largo on Groundwater Resources

Considering the development of the New Largo Colliery adjacent to Alternative A, the dewatering of the colliery could alter the groundwater drainage at the south of site A and result in an extra spreading of the ADF pollution plume at the south of the site A. If however the New Largo mine does not proceed, there would still likely be pollution from the historical underground mining operations that were situated on the New Largo Property.

4.3.3 Ecosystem Services at Risk

There is limited research on the ecosystem services delivered by groundwater aquifers. The delivery of ecosystem services from groundwater resources would be dependent on the type of aquifer, environmental factors such as recharge, rainfall and the extraction rate by anthropogenic sources. Broadly speaking groundwater aquifers could deliver the following services:

- Fresh water provisioning for agriculture, domestic use;
- Water regulation
- Water purification; and
- Habitat support services.

The selection of Alternative A is could have an impact on the quality of the groundwater by the percolation of leachate form the ADF into the aquifer. The likelihood of this occurring is unlikely due to the presence of a liner, which would prevent leachate entering the aquifer.

4.4 Surface Hydrology

The surface water specialist (Golder & Associates) adjudged Alternative C the preferred site with regards to the surface water impacts of the development. Alternative A and Alternative B are considered the second preferred alternatives and Alternatives GF, GA and FA would all have the worst potential impacts on the Wilge River.

While Alternative C is considered to be the preferred site for the positioning of the ADF from a surface hydrology perspective, it is important to note that Alternatives A and B are both the second preferred sites.

In terms of reduction in flow, the selection of Alternative A is expected to result in 1,6% lower on average for the year at the outflow of catchment B20F. While the selection of Alternative B is expected to be 0.78% lower on average for the year at the outflow of catchment B20F.

4.4.1 Environmental Description

The purpose of the surface hydrology report (Zitholele 2013) is to assess the potential impacts that the ADF options could have on the water resources at a quaternary catchment scale in terms of reduction of flow and deterioration of water quality.

Given the 60-year life, the ADF will cover an extensive area. The contribution of runoff and recharge of the area covered by the facilities to the water resource will be isolated by the stormwater management facilities and the ADF liner system. The water balance for the Olifants WMA is currently in deficit and the ADF will further reduce the volume of water reporting to the river system.

In terms of water quality impacts, the major impact is considered to be the leaching of ash residue into the surface water resources within the quaternary catchments. It can be expected that these variables of concern will impact on the surface water resources. However, this will be mitigated by disposing the ash on a barrier system that meets the requirements of hazardous waste disposal and will be sufficient to protect the environment in the long-term.

The watercourses that could be affected depending on the Alternative are:

- Alternative A and Small A: Holspruit and Klipfonteinspruit;
- Alternative B: Wilge River;
- Alternative C: unnamed non-perennial tributary;
- Alternative: Wilge River; and
- Alternative: Wilge River, Klipfonteinspruit and Kusile tributary.

The flow reductions from a quaternary catchment perspective as predicted by the modelling are small (<2%) for all the sites. In terms of water quality, it is likely that any of the sites could have an impact on the Wilge River from the tributaries running up and downstream of the Power Station site. Except for Site B, the sites are located within quaternary catchment B20F, the same catchment in which the Kusile Power Station is located.

Based on the alternative comparative assessment conducted by the specialist in terms of flow reduction and the deterioration of water quality, the following order of sites is recommended:

1. Alternative C;
2. Alternative B; and
3. Alternative A.
4. Alternatives GF, GA and FA would all have the worst potential impacts on the Wilge River.

With respect to water quality, for the selection of Alternative A potential seepage from the ADF could lead to contaminated run-off from the site with potential to contaminate downstream resources and small farm dams in catchment B20F. The cumulative impacts from Kusile Power Station (as well as New Largo) located immediately north of Alternative A would pose a higher risk to the environment. For Site B, Potential seepage from the ADF leading to contaminated run-off from the site with potential to contaminate downstream resources of both catchments B20F and B20G and small farm dams in streams north of the site. These streams would not be affected by the Kusile and New Largo developments. The conveyor corridor however would pose a concern where it would need to cross the Wilge River.

4.4.2 Ecosystem Services at Risk

The main ecosystem services produced by the surface water resources, which are at risk, are most likely to be water regulation and water quality. However, the flow reduction for all alternatives is expected to be at less than 2%, which is likely to have a reduced impact on water users within the affected quaternary catchments. Deterioration of water quality by the percolation of leachate form the ADF into the surface water resources is unlikely due to the presence of a barrier system, which meets the requirements of hazardous waste disposal and will be sufficient to protect the environment in the long-term.

4.5 Terrestrial Ecology

The specialist (Golder & Associates) adjudged Alternative GA, Alternative FA and Alternative FG as the preferred Alternatives. Alternative C is the next preferred alternative followed by Alternative A and finally, Alternative B.

4.5.1 Environmental Description

The study area is located in the Eastern Highveld Grassland and Rand Highveld Grassland vegetation types of the grassland biome (Mucina & Rutherford, 2006). According to Mucina & Rutherford (2006) both of these vegetation types are considered to be endangered. The subsequent assessment of alternatives is based largely on the ecological integrity (Figure 4-1) and the conservation importance of the vegetation communities (Figure 4-2).

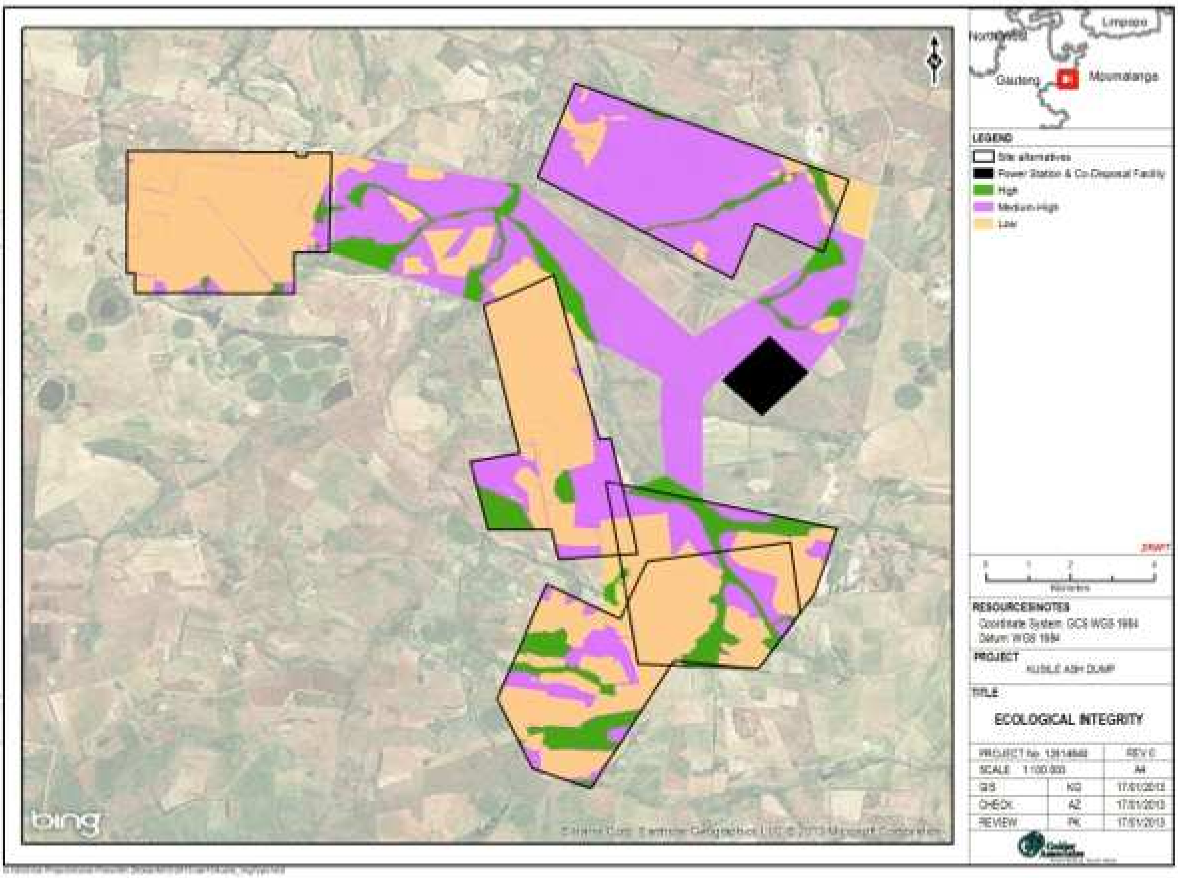

Figure 4-1. Ecological integrity of the vegetation communities (Source: Golder 2013)

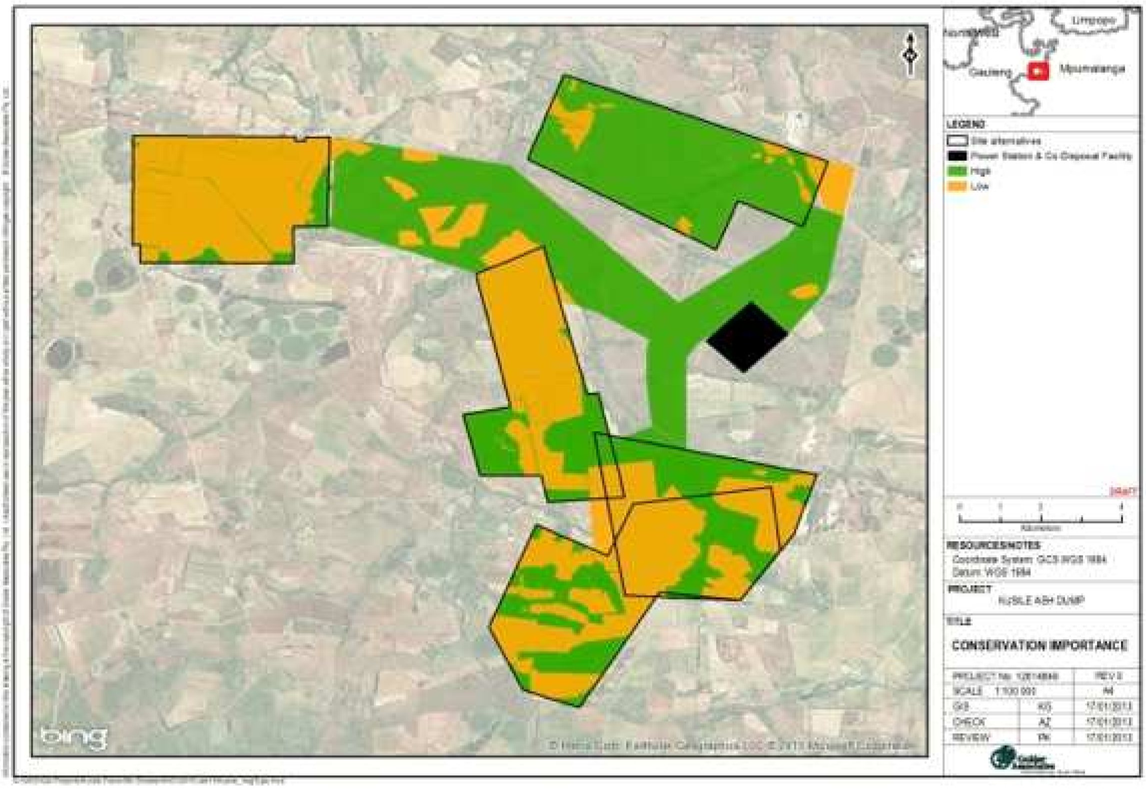

Figure 4-2. Conservation importance of vegetation communities (Source: Golder 2013)

From a terrestrial ecosystems perspective, selection of a preferred ADF site is therefore based on minimising the loss of important natural habitat and reducing the potential disruption of ecological processes. As such, the preferred site for the ADF should ideally be dominated by land of low ecological integrity and conservation importance (i.e. areas of cultivated land, Exotic woodlots and *Eragrostis* pastures) and where disturbance from the proposed conveyor will be minimal.

Taking ecological integrity and conservation importance into consideration Alternative F and Alternative G are the preferred sites for development, while Alternative C is the least preferred site due to its high ecological integrity. Although Alternative A is situated in close proximity to Kusile Power Station and comprises large areas of cultivated land, this site is characterised by important areas of wetland consisting of the moist grass and sedge community and adjacent Dry mixed grassland. These areas not only provide important habitat for a variety of fauna and flora, some of which may be Red Data/protected species, but the wetland areas will be of hydrological importance. Alternative A is therefore not a preferred site option.

4.5.2 Ecosystem Services at Risk

The loss of Alternative A would have an impact on the available habitat for species. The loss of the moist grass and sedge and adjacent dry mixed grassland communities could have implications for Red Data or protected species. However, it must be noted that in the analysis Alternative A scores relatively low in the ecological integrity scores and it is Alternative C which has the highest ecological integrity and is the most important from a terrestrial ecology point of view.

4.6 Avifauna Assessment

The specialists (Froneman & Van Rooyen) adjudged Alternative B as the preferred alternative in terms of impacts on avifauna. Alternative A was the second preferred, followed by Alternative AG, Alternative AF, Alternative FG and Alternative C.

Alternative B remains as the preferred alternative as the cumulative impact of losing another 1300 hectares of grassland bird habitat in the eastern Gauteng / Mpumalanga Highveld should be regarded as a moderate to high impact within the overall context of existing pressure on natural grassland habitat in the area. If, however, the development were located on existing agricultural lands (which constitutes the majority of the habitat on Alternative B), the cumulative impact would be lower, as the agricultural operations have already transformed the natural habitat completely.

4.6.1 Environmental Description

The purpose of the avifauna assessment is to understand the potential impacts posed by the 60 y ADF on avifauna species richness (Froneman & Van Rooyen 2013).

The Blue Crane *Anthropoides paradiseus* which is one of the priority avifauna species listed in the Mpumalanga Biobase Report (Emery et al. 2002) was recorded during the on-site surveys. Five Red Data bird species (Blue Crane, Lesser Kestrel *Falco naumanni*, Lesser Flamingo *Phoenicopterus minor*, Secretarybird *Sagittarius serpentarius* and Greater Flamingo *Phoenicopterus roseus*) which have been prioritized by the Gauteng Department of Agriculture, Conservation and Environment (GDACE) were recorded during the field surveys conducted in the area. Based on the surveys conducted and the best available information from the South African Bird Atlas Project - 17 Red Data species could potentially occur in the habitat types present in the study area.

The major factor influencing the selection of the site from an avifauna assessment is the presence of Red Data Species (Table 4-3). Alternative B has the lowest species richness ranking both from an all species as well as a Red Data species richness perspective. Alternative B is thus the most preferred alternative for the ash disposal facility from a bird impact perspective. Alternatives A and C are closely matched in terms of species richness but due to the more expansive natural grassland habitat present on Alternative C it emerged as the most sensitive and the least preferred for development.

Table 4-3. Red Data species richness index for the site alternatives

Site alternatives	**RD species richness index**	**Red data species Ranking**
Site B	2.8	1
Site G	7.8	2
Site F	8.1	3
Site F2	9.2	4
Site A	10.0	5
Site C	15.7	6

Taking into consideration the cumulative impacts of other known developments in their immediate vicinity, the ranking changes slightly, but Area B remains the preferred site (Table 4-4).

Table 4-4. Revised site alternative ranking taking the above cumulative impacts into consideration

Site Alternative	Rank taking cumulative impacts into consideration.
Site B	1
Site A	2
Site G	3
Site F2	4
Site F	5
Site C	6

4.6.2 Ecosystem Services at Risk

The loss of Alternative A would result in a loss of habitat for bird species. Although Alternative A scores high in the Red Data Species index, when taking the cumulative impacts into consideration Area A is the second most preferred site.

Ecosystem Service at Risk: Habitat for Bird Species

4.7 Bat Assessment

The specialist (EcoAgent) adjudged Alternative A as the preferred site for development of the ADF. Alternative GA is considered the second preferred site followed by B, C, FA and FG.

4.7.1 Environmental Description

According to the Bat Assessment, 17 insectivorous bats occur permanently or infrequently within a radius of 20 kilometres of the Kusile plant. Some of these species are common; others are ranked as Red Data species. Fruit bats are naturally absent (EcoAgent 2013).

Area A is considered the preferred site for establishing an ash disposal facility. Alternative GA (Areas G and Small A) would be a second choice. It is proposed that Alternative B is not selected because of its high agricultural potential and Alternative C for its high ecological value. Although Area F is tilled it is argued that it should be saved because of the neighbouring dams and endorheic pan.

When considering Alternative B, the specialist noted that the Site is uncomfortably close to the Wilge River and states that the unlikely leakage of noxious substances from the ADF will cause serious ecological damage, which will deleteriously affect bats (and other creatures subsisting at the apex of food pyramids) for a considerable distance downstream.

4.7.2 Ecosystem Services at Risk

The selection of Alternative A for the ash disposal facility will not directly impact on the 2013 s*tatus quo* of species richness and specific population dynamics, conditional to 100% containment of chemical contamination and minimizing the destruction of existing life-support opportunities (grasslands, roosting sites). Should there be unforeseen adverse environmental effects as result of the ash disposal facility, local bats will be displaced.

4.8 Air Quality Assessment

The specialist (Airshed Planning Professionals) adjudged Alternative A as the preferred site.

4.8.1 Environmental Description

For the Air Quality Assessment, The ash disposal facility alternatives were compared on the basis of four criteria: (a) the number of sensitive receptors at which the annual PM_{10} NAAQS were exceeded (for each alternative); (b) the area around each alternative where the annual PM_{10} exceeded the NAAQS; (c) the number of sensitive receptors at which the annual $PM_{2.5}$ NAAQS were exceeded (for each alternative); and, (d) the area around each alternative where the maximum dust-fall rate exceeded 400 $mg.m^{-2}day^{-1}$ (likely to result in impact to agriculture) (Airshed Planning Professionals 2013).

On the basis of these criteria Alternative A was the most preferred site followed by Alternative B. Alternative A is the preferred site for the Kusile 60-year ADF on the basis of air quality. Alternative B would be acceptable, but is not preferred due to the footprint and the distance from the power station terrace.

4.8.2 Ecosystem Services at Risk

The construction and operation of the Kusile ADF will have impacts on air quality regardless of its position. The selection of the preferred site was made under unmitigated conditions. By mitigating the potential for ash dispersal (by vegetating and wetting the surface of the dump) the air quality impacts can be reduced.

Ecosystem Service at Risk: Air Quality

4.9 Soils Assessment

The soil specialist ranked the Alternatives C, G, F, A and B.

4.9.1 Environmental Description

In determining the preferred site the soils assessment is dependent on three criteria:

Soils	Sensitivity of Soil Erosion Potential of Soil Soil Depth (ERD) Soil Structure and Workability
Land Capability	Arable potential Grazing Potential Wilderness Potential
Land Use	Presence of dwellings or people on the land Presence of Infrastructure Presence of livestock or cultivation on land

Taking these three criteria into account the specialist ranked the Alternative C, G, F, A and B.

However, if “Alternative B” is to be considered as a possible site, the following aspects need to be highlighted as outcomes of the soil and land capability studies:

- There are a significant number of both formal and some informal dwellings in the area of study,
- A significant amount of active commercial farming activities noted, with some intensive and high valued commercial farming associated with the proposed development area;
- Some commercial grazing and localised natural livestock farming;
- The land capability is considered to be of a moderate to good grazing and in places good arable land rating potential, and holds better than average potential for commercial utilisation.
- Significant area could, and is being utilised for high intensity commercial agriculture. Under well managed conditions;
- The percentage of wet based soils is confined almost exclusively to the lower lying areas off the site of proposed development;
- The soils are moderately easily, to easily worked and stored, albeit that erosion is an issue to be considered and managed (ESS 2013).

4.10 Social

The social specialist ranked the sites as follows: Alternative A, Alternative FA, Alternative FG, Alternative GA, Alternative B and Alternative C.

4.10.1 Environmental Description

The social impact study is mindful of the following impacts when determining a preferred site:

- Relocation of people (this is an extreme impact and should be avoided if at all possible);
- Impacts on livelihoods – this include breaking up of economic units, loss of land, water issues, dust and loss of labour;
- Impacts on quality of life – this includes impacts on sense of place, dust, noise and health;
- Impacts related to an influx of people – this includes impacts on physical and social infrastructure, health impacts, crime, safety and security, the integration of the workforce with existing communities and access to resources;
- Economic impacts (positive) – this includes job creation, skills development and opportunities for small and medium sized enterprises; and
- Economic impacts (negative) – this includes competition for jobs and possible community

When considering the possible social impacts Alternative A was considered to be the most preferred site, while Alternative C was considered the least preferred site (Table 4-5). One of the major considerations taken into account is the resettlement of communities. Alternative C contains families that were resettled from the site, which now contains the power station, so additional resettlement would be unacceptable. This can be seen as a fatal flaw and an unacceptable risk from a human rights and funding perspective.

Table 4-5. Social assessment site ranking (Source: Ptersa 2013)

Position	Alternative	Motivation
1	Alternative A	Most land already belongs to Eskom, thus resettlement will be kept to a minimum. Area is between Kusile Power Station and proposed New Largo Colliery, which make it less desirable for farming purposes. There is the potential to change the disposal area if the New Largo Colliery gets environmental approval (although this may not be practically executable due to issues like clashes between the mining schedule and when the area is needed, as well as mining method, which may not allow for this option).
2	Alternative GA	Most land on Site G already belongs to Eskom. Although economic units will be broken up on Site Small A, the Site is close to the proposed New Largo mining area, which makes it in all likelihood less desirable from a farming perspective than Site B.
3	Alternative B	Large economic farming units will be broken up, leading to loss of livelihoods and large resettlement costs. Located in different province (Gauteng) than rest of project (Mpumalanga) that may result in additional or different regulations and requirements to adhere to.
4	Alternative FG	There are land claims on Area F that may lead to considerable delays in the process. Most land already belongs to Eskom.
5	Alternative FA	There are land claims on Area F that may lead to considerable delays in the process. Large economic farming units will be broken up.
6	Alternative C	Families that were resettled for the Kusile Power Station will have to be resettled again. Resettlement causes severe social and economic impacts, and if it is not managed well it can cause a downward spiral of poverty. It takes years to mitigate this impact, and resettling communities that have been resettled recently will intensify the impact. It is contra-indicated in all the relevant international guidelines such as those of the IFC, the Asian Development Bank and Human Rights legislation. This can be seen as a fatal flaw and an unacceptable risk from a human rights and funding perspective.

Should Alternative B be chosen, there will be a severe impact on the livelihoods of a significant number of people, including farm workers who are seen as an extremely vulnerable group. It would be very difficult to recreate some of the livelihoods. Resettlement and compensation will be an expensive process given the fact that farms will need to be purchased as economic units, and some of the farms in the area are highly specialised. There will be down-stream social impacts on suppliers and food security.

4.11 Heritage Assessment

4.11.1 Environmental Description

The outcomes of the heritage assessment are based on the following attributes: graves and cemeteries, historic structures and palaeontology.

Graves and Cemeteries:
A total of just under 300 (±297) graves/cemeteries was identified throughout the five study alternatives. Alternative A contains two African farmworker cemeteries with ±37 graves together. Alternative C contains nine cemetery/grave sites with ±146 graves in total. Alternative F contains two grave/cemetery sites with up to 18 graves in total. Alternative G contains six grave/cemetery sites with a total of ±96 graves. These grave/cemetery sites include both African and European

graves. Some of the graves are definitely 60 years or older which makes them “heritage” graves; and many are of unknown date and should therefore be treated as being 60 years or older. Alternatives C and G have the most graves identified in total.

Historic Structures:

The total number of historic structures identified throughout the total study area (over the five alternative sites) is fourteen. Out of these, four historic farmhouses were identified, two of which may be of significance due to oral tradition associating them with the South African War (Anglo-Boer War). The other structures are the remains of historic kraals and worker homesteads.

Palaeontology:

The study area is mainly underlain by Vaalian aged rocks of the Daspoort, Silverton and Magalieberg Formations of the Pretoria Group and Permian aged sedimentary rocks of the Dwyka Formation and Vryheid Formation of the Ecca Group, which forms part of the Karoo Supergroup. Diabase occurs across the site in the form of Diabase sills.

There is a high possibility that fossils could be encountered during excavation of the Vryheid Formation. These fossil finds would be of international significance. The damage and/or loss of these fossils due to inadequate mitigation would be a highly negative palaeontological impact. The exposure and subsequent reporting of fossils (that would otherwise have remained undiscovered) to a qualified palaeontologist for excavation will be a beneficial palaeontological impact.

Based on these characteristics the following site selection was proposed by PGS (2013) (Table 4-6).

Table 4-6. Proposed site ranking based on heritage characteristics (Source: PGS 2013)

Site	Description	Rank
Alternative A	Site A seems to be one of the least heritage sensitive areas, with only two cemeteries (37 graves in total) and no heritage structures. At this stage, and compared to the other sites, this would make Alternative A the second most preferred alternative	2
Alternative B	Based on the satellite and topographical map analysis, there are 22 possible heritage sensitive areas that require further investigation by a field survey the third most preferred alternative	3
Alternative C	Due to the large number of graves, some of which are definitely heritage graves, and the presence of the two historic farmhouses, which will require further investigation; Alternative C is one of the least preferred options	6
Alternative GA	The option of Alternative GA would require a large amount of mitigation work for the identified grave/cemetery sites. This would make this option one of the least preferred options and rank it between the fourth and fifth alternative options	4
Alternative FG	Site F therefore has low heritage significance based on the fact that only two gravesites were identified, which together contain only +18 graves. Compared with the other sites, at this stage Alternative F is the least heritage sensitive and therefore the most preferred alternative for the development of the Kusile Ash Disposal Facility.	1
Alternative FA	The combination of Site F and Small A affects the least amount of identified heritage sites (including graves) than the combination of Site F and Site G and the mitigation of impacts on the identified graves should be more feasible to manage. This option is therefore a more preferred option than either the	1

	option Site F + Site G or the option of Sites G+Small A.	

4.12 Geotechnical Evaluation

4.12.1 Environmental Description

The geotechnical evaluation takes into consideration the following factors:

- Geology;
- Topography and terrain units;
- Seepage;
- Materials;
- Excavatability; and
- Soil profile;

The final ranking for the geotechnical study is as follows (Table 4-7):

Table 4-7. Alternative ranking for the geotechnical assessment

Alternative	Rank
A	1
B	4
C	5
F	3
G	2

5 SOCIO-ECONOMIC COST-BENEFIT ANALYSIS

5.1 Background on Methodology

A cost-benefit analysis (CBA) is useful for ensuring a balanced perspective and prioritised analysis of projects with multiple direct and indirect benefits and costs.

In the case under study, the direct benefit is to provide Eskom Kusile with an Ash Disposal Facility (ADF) site upon which to dispose ash produced during the coal-firing process. The Kusile Power Station will not be able to operate without this disposal site. Thus the indirect benefit of the ADF is to provide power generation capacity to the South African power generation grid. This has significant national benefit. In a CBA, these benefits come at financial and economic costs.

The financial costs are those costs incurred by Eskom, during the construction and operations of the ADF. The economic costs are those that are borne by society.

The cost-benefit analysis (CBA) follows international best practices in CBA methodology. Several methodologies are of interest here:

- The guideline of the European Commission on cost-benefit analysis of investment projects (2004). The methodology discussion in the rest of this section follows these guidelines.
- A manual for cost benefit analysis in South Africa with specific reference to water resource development (Mullins *et al* 2007).
- The Millennium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity (TEEB) frameworks of ecosystem services.

This rest of section is structured into two components:

- Financial analysis.
- Economic analysis.

5.1.1 Financial Analysis

While the CBA encompasses more than just the consideration of the financial returns of a project, most project data on costs and benefits is provided by financial analysis. This analysis provides information on inputs and outputs, their prices and the overall timing structure of revenues and expenditures. In most cases, the purpose of the financial analysis is to use a project's cash flow forecasts to calculate suitable return rates. However, in this case, because the ADF will not be a direct revenue generating activity, the financial analysis will be used to estimate the financial net present value (FNPV) of the different Alternatives, in order to compare Alternatives. The financial analysis is made up of a series of Excel tables that collect the financial flows of the investment, in this case broken down by

- Capital costs and
- Operating costs.

In order to correctly conduct the financial analysis for this study, careful attention must be paid to the following elements:

- Time horizon;
- The determination of total costs;
- Adjustment for inflation;
- Selection of the appropriate discount rate;
- Determination of the main performance indicators.

5.1.1.1 The Time Horizon

The time horizon is the number of years for which forecasts are provided. Forecasts regarding the future trend of the project should be formulated for a period appropriate to its economically useful life and long enough to encompass its likely mid/long term impact. In this case the time horizon is 65 years. This includes a 5-year licensing and initial construction period plus a 60-year construction and operations period. The analysis period therefore spans the period 2013 – 2078.

5.1.1.2 Determining Total Costs

The data for the cost of a project are provided by the sum of costs of capital and operating costs. These costs were estimated based on the conceptual designs for the ADF developed by Jones & Wagener Consulting Engineers.

5.1.1.3 Revenue Generated by the Project

The ADF forms a part of the Kusile Power Station Operations and will not generate any direct revenues. The FNPV of different options can be used to compare the contribution of the various options to electricity prices in South Africa.

5.1.1.4 Adjusting for inflation

In project analysis, it is often customary to use constant prices. This means that prices are adjusted for inflation and fixed at a base-year. However, in the analysis of financial flows, as is done here, current prices are more appropriate; these are nominal prices effectively observed year by year.

5.1.1.5 Determining the Discount Rate

To discount financial flows to the present and to calculate of net present value, the suitable discount rate must be defined. There are many theoretical and practical ways of estimating the reference rate to use to discount of the financial analysis. The key concept is that of the opportunity cost of capital.

In studies of this nature, the problem of inter-generational equity is addressed through the choice of discount rate. In a project of this kind, the investor, i.e. Government through Eskom may choose one discount rate for a decision on a return on investment, whereas Government acting in the public interest may choose another. To demonstrate this, it is normal to conduct a sensitivity analysis within a range of discount rates.

Eskom requires real internal rates of return (IRR's) for greenfields projects such as Kusile may vary between 4% and 8%. These "hurdle rates" are the discount rates for its investment decisions. These rates are the sums of the elements WACC (Working Average Cost of Capital), Contingency, Profit Margin and Operational Gearing. The choice of discount rate for public investment projects reflects both expectations about consumption growth and the social rate of time preference – the rate at which society prefers consumption today over consumption in the future. Formally,

$$r = \rho + \mu.g,$$

where

ρ	=	the social rate of time preference,
μ	=	the elasticity of the marginal utility of consumption, and
g	=	the marginal utility of consumption

The social rate of time preference is a welfare term. It measures the relative importance assigned by society to consumption by future generations. In South Africa, as in many countries in the developing world, the importance of improving the well-being of today's citizens implies a higher social rate of time preference than might be appropriate in high-income countries. In the UK, for example, the Green Book on appraisal of government investment recommends a rate of 3.5% for the first 30 years of any project, and low rates for projects evaluated over longer planning horizons. In this Study we apply a central rate of 4.00%, and test the sensitivity of the results to 6.00% and 8.00%.

5.1.1.6 Determination of Performance Indicators

The indicators used for financial analysis are:

- The financial net present value (FNPV) of the project;
- The contribution to electricity prices (Rand/kWh).

5.1.2 Economic Analysis

The economic analysis appraises the project contribution to and impacts on the economic welfare of the region / country. It is made on behalf of the whole society (region / country) instead of just the owner of the infrastructure like in the financial analysis.

The economic analysis, by means of the definition of appropriate conversion factors for each of the inflow or outflow items, outlines a table that includes benefits and social costs not considered by the financial analysis.

The logic of methodology allowing the transfer from financial to economic analysis consists of:

- The transformation of market prices used in the financial analysis into accounting prices (that amend prices distorted by market imperfections) and
- The consideration of externalities leading to benefits and social costs unconsidered by the financial analysis as they do not generate actual money expenditures or income (for example environmental impacts or redistributive effects).

As in the financial analysis, discounting is done based on the selection of a correct social discount rate and the calculation of the internal economic rate of return of the investment.

5.1.2.1 Fiscal Corrections

This part of the CBA leads to the determination of two elements for the economic analysis:

- The value of the 'fiscal correction' and
- The value of the conversion factor for market prices affected by fiscal aspects.

The following considerations are of importance:

- Prices of inputs and outputs to be considered for CBA should be net of VAT;
- Prices of inputs to be considered in the CBA should be gross of direct taxes;
- In some cases indirect taxes/subsidies are intended as correction of externalities. Typical examples are taxes on energy prices to discourage negative environmental externalities. In this case, and in similar ones, the inclusion of these taxes in project costs may be justified, but the appraisal should avoid double counting (e.g. including both energy taxation and estimates of external environmental costs in the appraisal).

5.1.2.2 Externalities Corrections

The objective of this part of the CBA is to determine external benefits or external costs not considered in the financial analysis. Examples are costs and benefits coming from environmental impacts, time saved, economic opportunity costs and others.

Sometimes valuing external costs and benefits may be difficult, even though they may be easily identified. In this case, some of the ADF impacts cause ecological damage, whose unmitigated effects, combined with other factors, will take place in the long run, and are difficult to quantify and value.

It is thus important to list the externalities, in order to give the decision-maker more elements to make a decision, by weighing up the quantifiable aspects, as expressed in the economic rate of return, against the unquantifiable ones (see multi criteria analysis above).

Externalities should be given a monetary value, if possible. If not, they should be quantified by non-monetary indicators. In this case, the nature of the comparative analysis allows for non-monetary analysis of ecosystem services effects.

5.1.3 The Calculation of the Economic Rate of Return

After the correction of price distortions it is possible to calculate the economic net present value (ENPV) and to compare the various Alternatives using this indicator (please note that the B/C ratio is not helpful in this analysis as the ADF does not produce a quantifiable direct revenue stream).

5.2 Financial Analysis and FNPV

The financial costs were derived from the conceptual design specifications and estimates provide by Jones and Wagener Consulting Engineers. Table 5-1 below summarises these costs.

The major cost components are:

- The construction capital costs associated with the lining system (on average = 37%),
- The conveyor costs (on average = 14%),

- ADF rehabilitation costs (on average = 16%), and
- Operations and maintenance costs (on average = 22%).

These costs together comprise (on average for all Alternatives) 89% of the total capital and operational costs. Therefore the most desirable Alternative from a financial perspective would be the Alternative with:

- The smallest footprint area (i.e. lowest construction capital cost and rehabilitation cost), and
- The shortest conveyor lengths (i.e. located closest to the Kusile Power Station) (this would also have the lowest operational costs).

The table below shows that Alternative A has the most preferred site from a financial perspective. The second most preferred is Alternative AG. However, the cost of Alternative AG exceeds that of Alternative 1 by 1.4. The financial costs of Alternatives B, C, 5 and FG exceeds that of Alternative A by 1.86, 1.65, 1.45 and 1.72 respectively.

Table 5-1. Comparison of conceptual design costs for the six Alternatives

Costs (R'M)	Alternative A	Alternative B	Alternative C	Alternative GA	Alternative FA	Alternative FG
Capital Construction costs	2,219	2,908	3,375	3,328	3,218	3,398
Capital costs for Clay	-	-	488	-	-	-
Conveyor Costs (Overland and Extendable)	831	1,713	1,752	1,063	1,292	1,336
Conveyor Costs (Shiftable)	255	224	215	240	240	205
Conveyor River Crossings	36	216	72	108	108	72
Starter Platform Earthworks	125	83	64	159	194	125
Pollution control dams	9	33	23	37	33	42
Diversions and prep costs	5	55	163	125	61	175
Stream Diversions	250	-	-	75	75	-
Rehabilitation Costs - ADF	822	1,077	1,250	772	1,192	1,964
Opex costs	816	3,897	1,528	1,654	1,378	1,998
Shifting costs	60	71	111	102	136	137
Total Construction Costs	5,429	10,276	9,041	7,663	7,924	9,450
Comparison between Alternatives	100%	186%	165%	140%	145%	172%

5.3 Indirect Benefits of the ADF

The ADF forms part of the operations of the Kusile Power Station and will thus not produce a direct revenue stream. However, the financial cost differential between the six Alternatives can be used to estimate the relative impact of the various Alternatives of electricity prices.

The cost of Alternative 1 to power generation is 0.23 cents/kWh. Alternative 4 would increase power generation costs by an additional 0.09 cents/kWh to 0.32 cents/kWh. Alternatives 2, 3, 5 and 6 would increase power generation costs by an additional 0.20, 0.15, 0.10 and 0.17 cents/kWh respectively (Table 5-2).

Table 5-2. Comparison of the impacts on electricity prices for the six Alternatives

	Alternative A	Alternative B	Alternative C	Alternative GA	Alternative FA	Alternative FG
Kusile capacity (MW)	4,800	4,800	4,800	4,800	4,800	4,800
Capacity factor (%)	95%	95%	95%	95%	95%	95%
KWh (Million)	39,946	39,946	39,946	39,946	39,946	39,946
Cents/kWh	0.23	0.43	0.38	0.32	0.33	0.40

5.4 Ecosystem Services

The Millennium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity (TEEB) provide sound and well-established frameworks for the assessment of ecosystems and their benefits to human well-being. These benefits are defined as ecosystem services. Both the MEA and TEEB define four categories of ecosystem services: provisioning services, cultural services, regulating services and supporting/habitat services.

Provisioning services cover the renewable resources that are mostly directly consumed and that generally have well-defined property rights. The cultural services capture many of the non-use (or passive use) values of ecological resources such as spiritual, religious, aesthetic and inspirational wellbeing.

Regulating services are indirect services that determine the capacity of ecosystems both to regulate the impact of external shocks, and to respond to changes in environmental conditions without losing functionality. The regulating services affect the distribution of outcomes, and in particular they affect both variation about the mean response and the likelihood of extreme responses. Supporting /habitat services capture the main ecosystem processes that support all other services.

Provisioning and cultural services are often highly tangible and/or their economic importance is easily recognizable.

Often less recognisable are the regulating services. Regulating services are a special category of ecosystem services, which are intermediate to the production of the provisioning and cultural services. Regulating services are not directly consumed in the economy. Rather, the value of the regulating services derives from the value of the final consumption services they protect (Simonit and Perrings, 2011).

Regulating services ensure the delivery of final consumption services over a range of environmental conditions (Perrings, 2006). Thus regulating services reduce risk to the economy. Regulating services can thus also be considered as providing an insurance value to the economy. This insurance value is important, not only to maintain economic resilience to seasonal environmental and economic changes, but also to long-term economic hazards, such as climate change.

The social opportunity cost of developments that change ecosystems would include the value of the resulting change in ecosystem services. This makes it possible to evaluate environmental impacts alongside the other costs and benefits of the development options, and so estimate the social value of development options *inclusive of environmental effects*[1].

It is important to recognize that the utilitarian values (the benefits consumed, used or enjoyed) of these services are not additive. Regulating services and supporting services can be considered to be similar to intermediate consumption in the economic sense. Provisioning and cultural services are those that enter final consumption. In order to avoid double accounting, only the final consumption services should be valued. The supporting and regulating services in the MEA system comprise the ecosystem functions and processes upon which the provisioning and cultural services depend. They are therefore embedded in those services, and are not evaluated separately, but through production functions. The value of these services is akin to an insurance value, as it regulates and insures the production of final consumption services.

[1] More than 1,360 international experts have contributed to the MA. The key outputs of the MA have been published in five technical volumes and six synthesis reports. These contain a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide (such clean water, food, forest products, flood control, and natural resources) and the options to restore, conserve or enhance the sustainable use of ecosystems (MA, 2007).

5.4.1 Provisioning Services

Provisioning services are principally those that deliver the goods or commodities that we easily recognise and which are often traded in markets.

Table 5-3. TEEB list of provisioning services

Types of services in the category	Definition according to TEEB	Relevance in the context of the ADF
Food	Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems but marine and freshwater systems or forests also provide food for human consumption. Wild foods from forests are often underestimated.	No evidence of wild food collection exists. Cultivated food values are internalised in land prices as a cost item in the financial analysis.
Raw materials	Ecosystems provide a great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly derived from wild and cultivated plant species.	No evidence of raw material collection from the wild exists. Cultivated raw material values are internalised in land prices as a cost item in the financial analysis.
Fresh water	Ecosystems play a vital role in the global hydrological cycle, as they regulate the flow and purification of water. Vegetation and forests influence the quantity of water available locally.	There is highly likely impact on water resources at all of the potential sites.
Medicinal resources	Ecosystems and biodiversity provide many plants used as traditional medicines as well as providing the raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources.	No evidence of raw medical resources collection from the wild exists.

5.4.2 Cultural Services

Cultural services include the largely intangible benefits of the ecosystem. These services and benefits are often the least understood and difficult to evaluate. It is especially difficult to compile an inventory of mutually exclusive cultural ecosystem services.

Despite these problems, cultural services may often be extremely valuable. For example, the book by Richard Louv (2005) refers to many clinical and psychological studies that reveal the benefits of ecosystem in terms of human health and psychosocial wellbeing. Hartig *et al* (2007), another example, summarises prior work as follows: “Our understanding of how the experience of nature might promote health has advanced through studies on environmental aesthetics, motivations for outdoor recreation, sources of residential satisfaction, and the affective and cognitive benefits of activities in gardens, parks, and wilderness areas”. A distinct theme in this work is the value of natural environments for psychological restoration, such as psycho-physiological stress reduction. This restorative value seems to stem from mutually reinforcing aspects of experiences of nature: distance from everyday demands, and possibilities for aesthetic appreciation and activity driven by interest.” In identifying these benefits enjoyed by humanity, Hartig *et al* also reveals the difficulties of classification and measurement (Crafford *et al* 2007).

Table 5-4. TEEB list of cultural services

Types of services in the category	Definition according to TEEB	Relevance in the context of the ADF
Recreation and mental and physical health	Walking and playing sports in green space is not only a good form of physical exercise but also lets people relax. The role that green space plays in maintaining mental and physical health is increasingly being recognized, despite difficulties of measurement.	No evidence of this ecosystem service at any of the sites. If ad hoc activities of this type take place by land owners they are assumed to be (a) the same for each of the Alternatives and (b) internalised in land prices as a cost item in the financial analysis.
Tourism	Ecosystems and biodiversity play an important role for many kinds of tourism, which in turn provides considerable economic benefits and is a vital source of income for many countries. Cultural and eco-tourism can also educate people about the importance of biological diversity.	No evidence of this ecosystem service at any of the sites. If ad hoc activities of this type take place by land owners they are assumed to be (a) the same for each of the Alternatives and (b) internalised in land prices as a cost item in the financial analysis.
Aesthetic appreciation and inspiration for culture, art and design	Language, knowledge and the natural environment have been intimately related throughout human history. Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science.	No evidence of this ecosystem service at any of the sites. If ad hoc activities of this type take place by land owners they are assumed to be (a) the same for each of the Alternatives and (b) internalised in land prices as a cost item in the financial analysis.
Spiritual experience and sense of place	In many parts of the world natural features such as specific forests, caves or mountains are considered sacred or have a religious meaning. Nature is a common element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging.	Evidence exists that (a) there are grave sites which have spiritual and/or religious importance, and (b) at Area C there are several communities who have previously been located to this site and who would be expected to have a Sense of Place connection to Site C.

5.4.3 Supporting and Regulating Services

The table below lists the supporting and regulating services normally to be found in an inventory of ecosystem services. These services define the underlying ecosystem components and processes that produce the final ecosystem service units, provided through the provisioning and cultural services.

The service defined as waste treatment requires discussion. When business and household emissions are disposed of in ecosystems, those business and households receive a form of benefit from the ecosystems. This is because the ecosystems are used as a disposal area without the businesses and households having to pay for it. The alternative would have been for the relevant businesses and households to forego some of their net income to pay for the treatment of the emissions.

Table 5-5. TEEB list of supporting/habitat and regulating provisioning services

Types of services	**Description**	**Relevance in the context of**

in the category		**the ADF**
Category of ecosystem service: supporting/habitat		
Habitats for species	Habitats provide everything that an individual plant or animal needs to survive: food; water; and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements.	Every one of the Alternatives would affect about 1,000ha of different types of habitat.
Maintenance of genetic diversity	Genetic diversity is the variety of genes between and within species populations. Genetic diversity distinguishes different breeds or races from each other thus providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as 'biodiversity hotspots'.	None of the sites put genetic diversity at risk
Category of ecosystem service: regulating		
Local climate and air quality	Trees provide shade whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere.	Unmitigated ADF management would affect air quality through windblown dust and thus put human and ecosystem health at risk.
Carbon sequestration and storage	Ecosystems regulate the global climate by storing and sequestering greenhouse gases. As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues. In this way forest ecosystems are carbon stores. Biodiversity also plays an important role by improving the capacity of ecosystems to adapt to the effects of climate change.	It is likely that wetland habitat has a carbon sequestration function, and thus the risk to wetland habitat would put this ecosystem service at risk.
Moderation of extreme events	Extreme weather events or natural hazards include floods, storms, tsunamis, avalanches and landslides. Ecosystems and living organisms create buffers against natural disasters, thereby preventing possible damage. For example, wetlands can soak up flood water whilst trees can stabilize slopes.	It is possible that wetland habitat has a flood attenuation function, and thus the risk to wetland habitat would put this ecosystem service at risk.
Waste-water treatment	Ecosystems such as wetlands filter both human and animal waste and act as a natural buffer to the surrounding environment. Through the biological activity of microorganisms in the soil, most waste is broken down. Thereby pathogens (disease causing microbes) are eliminated, and the level of nutrients and pollution is reduced.	It is highly likely that wetland habitat has a waste-water treatment function, and thus the risk to wetland habitat would put this ecosystem service at risk.
Erosion prevention and maintenance of soil fertility	Soil erosion is a key factor in the process of land degradation and desertification. Vegetation cover provides a vital regulating service by preventing soil erosion. Soil fertility is essential for plant growth and agriculture and well functioning ecosystems supply the soil with nutrients required to support plant growth.	It is highly likely that terrestrial and wetland habitat have erosion prevention functions, and thus the risk to these habitats would put this ecosystem service at risk.
Pollination	Insects and wind pollinate plants and trees which is essential for the development of fruits, vegetables and seeds. Animal pollination is an ecosystem service mainly provided by insects but also by some birds and bats.	This service is not at risk.
Biological control	Ecosystems are important for regulating pests and vector borne diseases that attack plants, animals and people.	This service is not at risk.

	Ecosystems regulate pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls.	

5.4.4 The Economic Value of Aquatic Ecosystem Services in the Olifants WMA

The tables above demonstrate that, for the most part, the ADF would put aquatic ecosystem services at risk. The estimation of the value of aquatic ecosystem services is done through environmental and resource economics (ERE) studies. ERE studies seek to value the stream of benefits delivered by the set of ecosystem services associated with an ecosystem. The Department of Water Affairs published an ERE study on the ecosystem services of the Olifants WMA in 2012 (DWA 2012).

This study valued the combined provisioning and cultural ecosystem services produced by water resources at approximately R3 billion in 2010. This represents more than 2% of the contribution to GDP generated within the catchment. Furthermore, aquatic supporting and regulating services were found to underlie more than 50% of the contribution to GDP in the local economy, or more than R70 billion per year. This is because of extensive reliance of the economy on water use licences.

Wetlands form a key part of the ecological infrastructure of the Olifants aquatic ecosystem. According to SANBI's NFEPA (National Freshwater Ecosystem Priority Areas) database, the Olifants WMA has more than 126,000 ha of wetland area.

Table 5-6. Summary of adjusted ecosystem service values (2009 Rands), excluding waste absorption for each of the sub-catchments of the Olifants WMA (Discrepancies may occur due to rounding)

Ecosystem services produced by Rivers					
R'Million	**Upper Olifants**	**Middle Olifants**	**Steelpoort**	**Lower Olifants**	**Total**
Water shadow price	na	na	na	na	280.3
Domestic water use	16.5	232.1	85	54.5	388.1
Livestock watering	0	45.1	10.1	10.7	65.9
Harvested products	11	28.2	10.2	17.5	66.9
Carbon Sequestration	0.1	1	0.2	1.4	2.7
Tourism	37.4	38.4	38.8	249.6	364.2
Recreation	5.1	5.3	5.3	34.3	50.1
Aesthetic value				22.32	22.32
Education	0.1	0.2	0.1	0.1	0.5
Sub-Total	**70**	**350**	**149**	**373**	**1,224**
Ecosystem services produced by Wetlands					
R'Million	**Upper Olifants**	**Middle Olifants**	**Steelpoort**	**Lower Olifants**	**Total**
Grazing	48.5	11.4	8.1	4.0	72.0
Livestock watering	60.19	304.97	4.45	64.35	398.40
Harvested products	24.69	86.85	66.70	45.22	174.74
Flood attenuation	14.20	2.02	1.78	0.70	19.22
Carbon Sequestration	4.01	1.01	0.44	0.35	5.94

Angling	5.09	1.01	-	-	6.64
Tourism	6.64	3.23	1.33	4.00	14.85
Recreation	0.9	0.4	0.2	0.6	2.0
Sub-Total	**115**	**399**	**74**	**115**	**705**
Grand Total (2009)	**186**	**750**	**225**	**489**	**1,930**

Water pollution is a particular and severe problem within the Olifants WMA. Poor water quality detrimentally affects economic activities such as irrigation productivity, operation and maintenance cost of water infrastructure, subsistence fishing, recreation, tourism and human health.

The Olifants River Water Resources Development Project (DWA 2005) describes water quality in the whole of the Olifants River to be in a crisis. In the Upper Olifants water quality in the Olifants River is greatly affected by the wide variety of mining operations that take place all over the catchment. The available evidence suggests that the extensive coal mining in the region has had, and will continue to have, very high impacts on water resources, particularly water quality in all streams and rivers. The primary cause of the degradation is the extensive acid mine drainage where water of low pH, with high concentrations of total dissolved salts and metals, enters local watercourses. This results in a complete change in water chemistry. It is estimated that some 62 million m^3 of water decants from closed or abandoned mine workings each year. The large volumes of acid mine drainage and the long period of time over which these discharges and seepages have taken place has resulted in the impacts still being discernible (as altered water chemistry characteristics) over two hundred kilometres downstream from the Witbank and Highveld Coalfields. These effects may also be accentuated by seepages from unlined power station ash dumps, as well as effluent discarded by different industries and the larger municipalities (DWA 2004, DWA 2005).

A water quality load model was set up for the Olifants WMA and potential RQO requirements were analysed at a representative EWR site at each IUA. The value of the waste absorption ecosystem service was estimated to be between R 880 million in 2010.

5.4.5 Summary of Ecosystem Services Affected

Based on the assessments above, several ecosystem services values need to be considered, these are set out in Table 5-7 below. Several possible valuation techniques are available, and are subject to the analyses described above. These ecosystem services include:

Table 5-7. Ecosystem services at risk for the various Alternatives

Affected ecosystem services	Likelihood	Consequence	Risk	Economic value	Mitigation
Fresh water	Possible	Minor	Medium	Insurance value	To be determined
Spiritual experience and sense of place	Possible	Minor	Medium	Damage cost	Relocation of dwellings and graves
Habitats for species	Almost certain	Minor	Medium	Damage cost	Wetland and grasslands rehabilitation
Carbon sequestration and storage	Likely	Minor	Low	Damage cost	Wetland rehabilitation
Moderation of extreme	Likely	Minor	Low	Damage cost	Wetland rehabilitation

events					
Waste-water treatment	Possible	Minor	Medium	Damage cost	Sediment management, artificial wetlands, wetland rehabilitation
Erosion prevention and maintenance of soil fertility	Possible	Minor	Medium	Damage cost	Sediment management, artificial wetlands, wetland rehabilitation
Local climate and air quality	Likely	Minor	Low	Health cost	Wetting, rehabilitation

5.4.6 Prevention of Damage Costs and the Mitigation Sequence

In cases where ecosystem service values are difficult to quantify, it is often useful to take a damage prevention approach. This approach is also entrenched in both National Environmental Management Act and the National Water Act.

A very useful approach for analysing damage prevention is the concept of the Mitigation Sequence, as defined by the United States Environmental Protection Agency (EPA). This sequence identifies a three-tiered approach to limiting wetland impacts, through: avoidance, mitigation and compensation.

Some confusion exists in literature with respect to the natural progression of activities that seek to minimise damages to ecosystem services. In South Africa for instance, SANBI recently published a draft document on wetland-offset guidelines (SANBI 2012). The document defines a mitigation hierarchy but does not define in adequate detail all the relevant aspects of the hierarchy. Neither does it link these aspects sufficiently to ecosystem services. The linkage to ecosystem services is of particular importance since ecosystem services losses represent damages to downstream beneficiaries and thus also liabilities to project developers (in this case Eskom).

However, the United States Environmental Protection Agency (EPA) proposes a very useful way for defining ecosystem impacts, through their Mitigation Sequence. The EPA established this in a 1990 Memorandum of Agreement (MOA) between the EPA and the Department of Defense, as a three-step process. The three steps include:

- Step 1. Avoid: Adverse impacts to aquatic resources are to be avoided and no impact shall be allowed if there is a practicable alternative with less adverse impact.
- Step 2. Minimize: If impacts cannot be avoided, appropriate and practicable steps to minimize adverse impacts must be taken.
- Step 3. Compensate: Appropriate and practicable compensatory mitigation, which includes offsetting, is required for unavoidable adverse impacts, which remain. The amount and quality of compensatory mitigation may not substitute for avoiding and minimizing impacts.

Methods of compensatory mitigation include restoration, establishment, enhancement and preservation. Restoration includes re-establishment or rehabilitation of aquatic resources with the goal of returning natural or historic functions and characteristics. Establishment involves the development of aquatic resources where it did not previously exist, through manipulation of the physical, chemical and/or biological characteristics of the site. Enhancement includes activities conducted within existing aquatic resources that heighten, intensify, or improve one or more wetland functions. Enhancement may be undertaken for a specific purpose such as to improve water quality, flood water retention or wildlife habitat. Preservation includes the permanent protection of ecologically important aquatic resources through the implementation of appropriate legal and physical mechanisms (EPA 2012). Only after all these measures have been exhausted should monetary compensation be considered.

5.4.6.1 System Considerations for Avoidance, Minimization and Compensation

The system analysis presented above identifies three key system components that need to be considered in the mitigation sequence for the ecosystem services impacts of the Kusile ADF site:

- Avoiding and minimizing impacts on the Wilge River
- Avoiding, minimizing and off-setting of wetland and terrestrial habitats
- Avoiding, minimizing and compensating for socio-economic impacts.

5.4.6.2 Steps Taken to Avoid and Minimise Ecosystem Impacts

The ADF conceptual design process has taken a number of steps to avoid and minimise.

This included the following avoidance measures:

- During site selection at scoping phase sensitive ecosystems and high potential agricultural land were avoided as far as possible;
- The design of the ADF was optimised as far as possible to minimise the ADF footprint;
- Suitable conveyor crossing points of rivers and wetlands were identified;
- Dual ADF sites (Alternatives 4, 5 and 6) were specifically included to avoid wetland impacts.

This included the following mitigation measures:

- Compulsory dust suppression measures including consecutive ADF rehabilitation;
- Stormwater management measures during construction (such us sediment traps);
- Clean and dirty water separation during operation;
- Meeting of design requirements for storage of contaminated water (GN 704);
- Eskom Standard Management Plans for Terrestrial Ecology, Fire Management, Land Use Management;
- Search and Rescue Operations for fauna and flora;
- Housing on conveyor;
- Monitoring and pumping boreholes to be installed around the facility to ensure that the water level is retained >5 m below the barrier system ("Cut-off Curtain").

5.4.6.3 Considerations Proposed to Minimise and Offset Residual Impacts

None of the available Alternatives entirely avoids impacts on ecosystem services. The final site selection should therefore minimise and offset residual impacts. The site selection section (Section 4) above summarises expert opinion on the minimisation and offsetting of residual impacts. These opinions, read in context of the systems analysis (Section 3) and the outputs of Table 5-7 provides a strong case for a landscape rehabilitation plan associated with the Kusile ADF. Such a landscape rehabilitation plan would have to:

- Minimise water flow and quality effects on the Wilge River
- Minimise erosion in the system

- Offset wetland impacts
- Relocate graves.

6 PREFERRED ALTERNATIVE

6.1 Relative Benefits of Alternative A

Alternative A emerges as the preferred Alternative.

The benefits of Alternative 1 include:

- Lowest inferred ecosystem cost (i.e. most preferred) Alternative by the following specialists
    - Wetlands specialist
    - Aquatic ecosystems specialist
    - Groundwater specialist
    - Social specialist
    - Bats
    - Air Quality
    - Soils specialist
    - Traffic specialist
    - Engineering specialist.
- Highest minimisation and offset potential area (refer to Section 6 below);
- Least number of dirty water dam controls (one only on the Klipfonteinspruit, more than 6.5 km from the Wilge River) - this limits the risk of water pollution and maximises the ability to mitigate impacts on the Wilge River;
- Lowest cost Alternative to Eskom (Table 5-1);
- Lowest cost Alternative to electricity users (Table 5-2).

Alternative A has the following negative impacts, which need to be addressed in a mitigation strategy (see Section 6 below):

- It has 227 ha of wetland area and associated terrestrial habitat that would have to be offset;
- It contains graves that need to be relocated.

6.2 Rationale for Eliminating Alternatives

6.2.1 Alternative B

Alternative B has the following key negative impacts:

- The conveyor servitude would have to cross the Wilge River – this is an activity that needs to be avoided due to potential risks to the Wilge River;
- This Alternative requires seven dirty water dam capture sites on the Wilge River and several of its tributaries – this increases the risk of water pollution and limits the ability to mitigate impacts on the Wilge River;
- The FNPV exceeds that of Alternative 1 by 1.86 and increases costs to electricity users.

6.2.2 Alternative C

Alternative C has the following key negative impacts:

- A previously relocated community resides on Alternative C;
- This area is located less than 200m from the mainstem of the Wilge River;
- There is evidence of Red Data Birds breeding on Alternative C (and foraging on Site F);
- This Alternative requires a borrow pit, to be located at Alternative A, which will significantly increase the footprint of this Alternative;
- This Alternative requires five dirty water dam capture sites on the Wilge River and several of its tributaries – this increases the risk of water pollution and limits the ability to mitigate impacts on the Wilge River.

6.2.3 Alternative GA

- This area is located less than 200m from the mainstem of the Wilge River;
- There is evidence of Red Data Birds (breeding on Alternative C and) foraging on Site F;
- This Alternative requires five dirty water dam capture sites on the Wilge River and several of its tributaries – this increases the risk of water pollution and limits the ability to mitigate impacts on the Wilge River;
- The FNPV exceeds that of Alternative A by 1.40 and increases costs to electricity users – this is because of the dual site design required in this Alternative.

6.2.4 Alternative FA

- This area is located less than 200m from the mainstem of the Wilge River;
- There is evidence of Red Data Birds (breeding on Alternative C and) foraging on Site F;
- This Alternative requires seven dirty water dam capture sites on the Wilge River and several of its tributaries – this increases the risk of water pollution and limits the ability to mitigate impacts on the Wilge River;
- The FNPV exceeds that of Alternative A by 1.45 and increases costs to electricity users – this is because of the dual site design required in this Alternative.

6.2.5 Alternative FG

- These areas are both located less than 200m from the mainstem of the Wilge River;
- There is evidence of Red Data Birds (breeding on Alternative C and) foraging on Site F;
- This Alternative requires six dirty water dam capture sites on the Wilge River and several of its tributaries – this increases the risk of water pollution and limits the ability to mitigate impacts on the Wilge River;
- The FNPV exceeds that of Alternative A by 1.72 and increases costs to electricity users – this is because of the dual site design required in this Alternative and the undesirable topography of the site.

7 MINIMISATION AND OFFSETTING CONSIDERATIONS

7.1 Preliminary Mitigation Plan

7.1.1 Rationale

With the strategic importance of the Wilge River in the Upper Olifants WMA, it is important that the impacts expected from the construction and operational phase of the 60 year ADF (as well as other Kusile infrastructure) on surface water resources be mitigated as best as possible. To this end, Eskom is currently completing a Memorandum of Understanding (MOU) with the South African National Biodiversity Institute (SANBI) in order to provide guidance on designing a wetland offset and mitigation programme that takes cognisance of the SANBI Wetland Offset Guidelines currently under development. The inclusion of SANBI in the process was requested by DWA in the meeting held on the 14th August 2013 at the DWA head office in Pretoria.

The Mitigation Plan however, is not solely designed around the protection of aquatic ecosystems, but will also include aspects of the impacted terrestrial habitat and heritage features such as gravesites.

7.1.2 Overview of Preliminary Mitigation Plan

What follows below is a preliminary draft on the areas that have been identified as possible areas for offset activities to take place. It is important to note that these areas are preliminary and will change when the wetland and terrestrial ecologist specialists have completed a full, comprehensive study. The scope of the study would be to identify areas formally and determine whether offsets are feasible in terms of the proposed area ratios and the total functionality of the wetlands to be lost. The specialist study is expected to begin at the end of January 2014.

The purpose of the identified areas is thus twofold; firstly to identify wetland areas that may be suitable for offsetting wetland loss caused by the construction of Kusile and secondly, buffer the Wilge River from any other impacts which may be caused by Kusile in the near future.

Eskom Kusile has recently developed a Draft Wetlands Management Strategy. This document identifies various wetland rehabilitation options. These options rely on a landscape approach of the B20F quaternary catchment, which includes sensitive and threatened habitats, species and vegetation units, comprising riparian zones, wetlands and terrestrial grasslands. It takes cognisance of the fact that both riparian zones and wetlands exist within a matrix of other landscape units and are not divorced from them, often relying on the integrity, intactness and functionality of these units for their own functionality and status. Figure 7-1 below outlines five (5) major components within the B20F quaternary catchment that provide options for an overall strategy for wetland management.

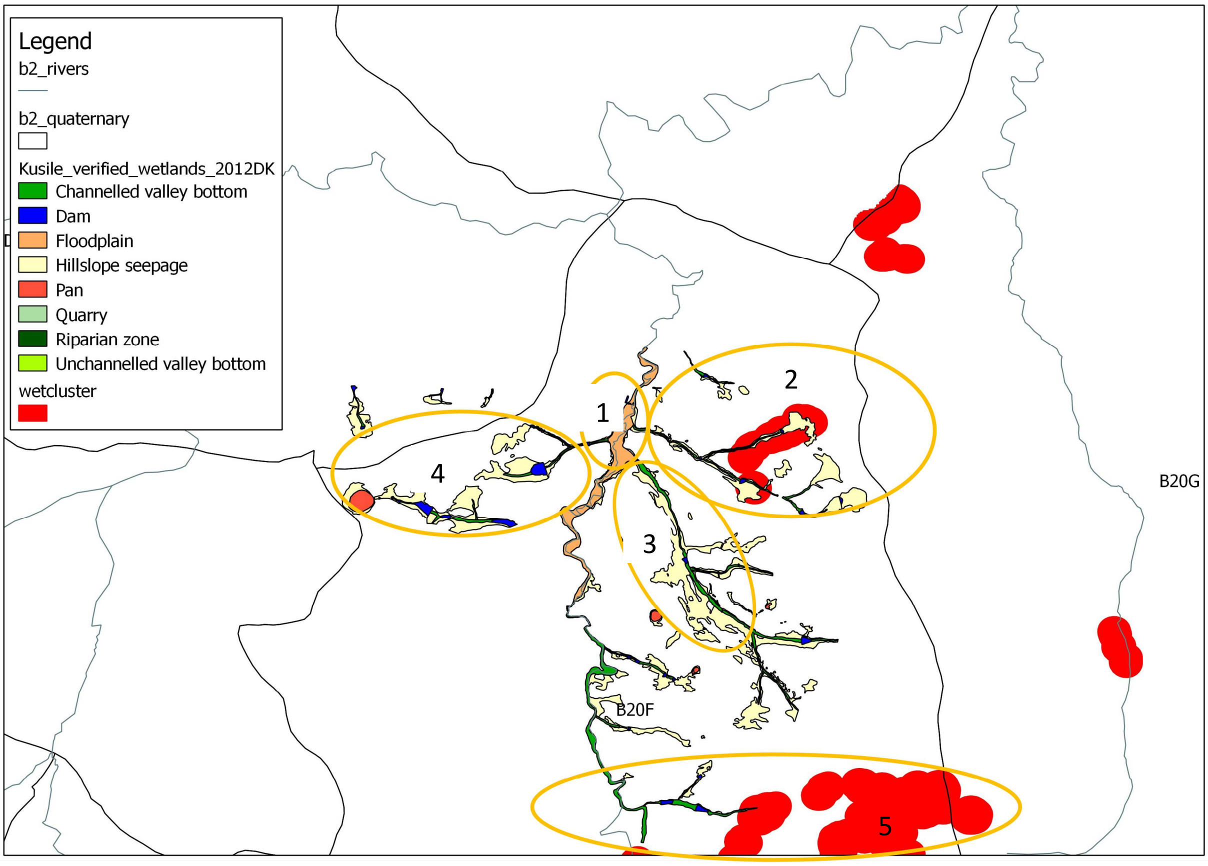

Figure 7-1. Landscape overview of the B20F quaternary catchment indicating 5 major components (A to E) to a proposed overall wetland management strategy

Component 1 is the Wilge River noted and assessed as SQ B20F-01150 (SQ = sub-quaternary). This portion of the Wilge River is 44.2 km within the quaternary and has only 43% natural landcover within 500m of the channel (National Landcover Data). The Wilge River also gives rise to large areas of floodplain wetlands. The SQ has recently been assessed for ecostatus (PES = C) and Ecological Importance (EI) and Sensitivity (ES) (both are Moderate), (Louw *et al.* in press). The main impacts in this area are agricultural lands, abstraction and alien vegetation invasion.

Component 2 is dominated by hillslope seepage and channelled valley-bottom wetlands. A significant portion of these wetlands falls within Area C (146 ha; a proposed 60 Year ADF), with the remainder, extensive in area, occurring between Alternative C and Kusile power station itself. Together, these wetlands lumped as component 2 feed into the main Wilge River, so any management of this component that improves functionality will also positively affect the Wilge River. Most of the wetlands within Alternative C are recognised as an important wetland cluster (wetcluster, Nel *et al.*, 2011) with sightings of both Blue Cranes and Secretary Birds. The majority of the wetlands are in a “C” or “D” category, with a significant proportion in “D”. Since the main impacts include elevated storm water with consequent erosion, agricultural activities, high trampling pressure (mostly cattle) and dams there is a high potential for rehabilitation of wetlands (and uplands) with a high probability of achieving significant improvement in PES.

Component 3 is dominated by hillslope seepage wetlands with some channelled valley-bottom wetlands and a small portion of floodplain wetlands at the confluence with the Wilge River. The majority of these are category “C” wetlands with some “A” and “D”. The wetlands in component 3 will be directly impacted by activities at Kusile as well as the proposed Kusile ADF if authorised at site A. They therefore form an extensive “buffer” between Kusile and the Wilge River and it is proposed to use this to the advantage of both protecting downstream habitats from elevated flows or sediments and improving the PES of a portion of downstream wetlands.

Component 4 is dominated by hillslope seepage wetlands with some channelled valley-bottom wetlands and a pan. Approximately 50% of the wetlands in this area are category “D” wetlands, with some “C” and a large proportion of “B” wetlands. Some of these occur within Alternative B (an option for the 60 Year ADF). Main impacts are agriculture and increased wetness due to irrigation runoff / seepage.

Component 5 comprises several wetland clusters noted for national importance (wetcluster, Nel *et al.*, 2011). They fall outside of the original area assessed but occur within the quaternary catchment. Most of cluster 5 would appear to fall within the New Largo footprint. If the wetlands in this area are not mined by New Largo, they will likely be targeted by New Largo for offsets and will not be available to Kusile. While further investigation of the area is required, it is unlikely that it would be available for rehabilitation.

A proposed strategy for overall wetland rehabilitation of the B20F quaternary within a landscape context is outlined below, and is intended to serve as sufficient wetland offset requirements. The steps indicated below are not intended to be prescriptive at this stage, nor are they exhaustive but merely provide a conceptual framework that will require more detailed planning and development. In all cases rehabilitation is intended to improve the overall PES of wetlands, especially where category “C” and “D” wetlands occur:

1) Rehabilitation of the Wilge River and associated floodplain wetlands (Component 1). The PES can be improved and a category “B” may be achievable if alien plants are removed and agricultural encroachment is curtailed by moving crops out of floodplain wetlands. If land is owned or purchased, terrestrial rehabilitation of grasslands is also possible which will enhance overall ecosystem resilience. The rehabilitation potential of the Wilge River is high.
2) Rehabilitation of wetlands outlined in Component 2, especially those associated with the NFEPA wetland cluster, those that occur within Alternative C (an option for the 60 Year ADF) and those already impacted by activities associated with Kusile. The area lends itself to the development of a nature reserve within which both terrestrial and wetland habitats are rehabilitated, with the added possibility of incorporating local communities into the reserve management/ownership. Rehabilitation potential is high and would involve *inter alia* reducing cattle or replacing with natural grazers, reducing dams (in both number and size i.e. reduce dam wall height), removing artificial levees, developing effective storm water runoff management and removing alien woody species (particularly Bluegums and Poplars). The main drainage line of Component 2 (parallel to southern boundary of Component 3) is also heavily impacted by Kusile in terms of turbidity, though this is not yet reflected in the

aquatic ecology as much as for the Klipfonteinspruit. However, additional interventions to deal with altered flows and turbidity (e.g. small retention dams or upgrade of existing dams) might also be considered for the upper reaches of this drainage line.

3) Some of the wetlands in component 3 will be lost in Alternative 1 and it is proposed that a portion of wetlands closest to the new ADF be "sacrificed" to protect downstream habitats. This would entail utilising an upstream portion of the wetlands to mitigate impacts by installing a series of small retention dams that would trap sediments, improve water quality and disperse runoff. The area required for the retention dams, as well as the capacity of the retention dams, will need to be determined through detailed hydrological modelling. The result would be some portion of upstream wetlands essentially becoming artificial in nature, but retaining desired ecological functions and at the same time protecting and improving downstream ecostatus. The majority of wetlands in the area however are to undergo rehabilitation. A significant portion of the wetlands in Component 3 is associated with agricultural activities in Alternative F where irrigation and artificial runoff is high (and polluted), and disturbance activities promote alien weed success essentially ensuring an efficient refuge of alien weeds that encroach into the wetlands. Rehabilitation of terrestrial grasslands in this area, while not an activity directly associated with wetlands, will effectively enhance the ecostatus of wetlands within a grassland matrix by reducing the source of alien plant species, erosion and elevated runoff. Wetlands in this area also have the potential for the development of a conservation area, and could easily be joined to Component 2. Specific rehabilitation activities could include the removal of the existing breached dam wall near the Wilge River and restoration of the floodplain, the removal of alien plant species, the restoration of upland grasslands (which are also a threatened vegetation unit type).
4) Rehabilitation of wetlands outlined in Component 4, especially those that occur within Alternative B. Rehabilitation of wetlands in this area will be more difficult to achieve since the major impact is related to agricultural encroachment and irrigation and would more than likely require the purchase of land to operationalise.
5) This may not be a viable option but would entail investigating the possibility of improving wetland ecostatus of several NFEPA wetland clusters outlined in Component 5.

Steps 1, 2 and 3 outlined above will significantly improve wetland condition, functionality and integrity within component areas. Should several of the steps become operational it would significantly improve overall wetland (and riparian and terrestrial) ecostatus of the B20F quaternary.

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APPENDIX 1: SYSTEMS DESCRIPTION

Geology

The geology description is taken from the Biophysical Study: Groundwater Assessment (2013) Report by Aqua Earth Consulting. The analysis is based on the "1/250 000 Geological Series: 2528 Pretoria "and the "1/250 000 Geological Series: 2628 East Rand" published respectively in 1978 and in 1986 by the Government Printer.

The prevailing formations in the area are Ecca, Dwyka (found in the pre-Karoo topography), and Vryheid of the Karoo Sequence; Rayton, Magaliesberg, Sylverton, Daspoort, and Strubenkop of the Pretoria Group; and Loskop of the Rooiberg Group. The Karoo sequence in the area is associated with some shale, shaly sandstone, sandstone, conglomerate, tillite, and coal. The Pretoria Group in the area consists of quartzite, shale, subgraywacke, hornfels, carbonaceous, and chert. The Rooiberg Group is composed of agglomerate and lave. Some diabase sills have also been noticed in the study area during previous geological explorations, and are particularly associated with the Silverton formation. Some granite of the Bushveld Complex, and some Pyroxenite, gabbro, and anorthosite of the Dwarsfontein Suite are also expected as intrusive rocks in the south-west of the study area. The expected distribution of such lithologies in the study area is as shown in the figure below.

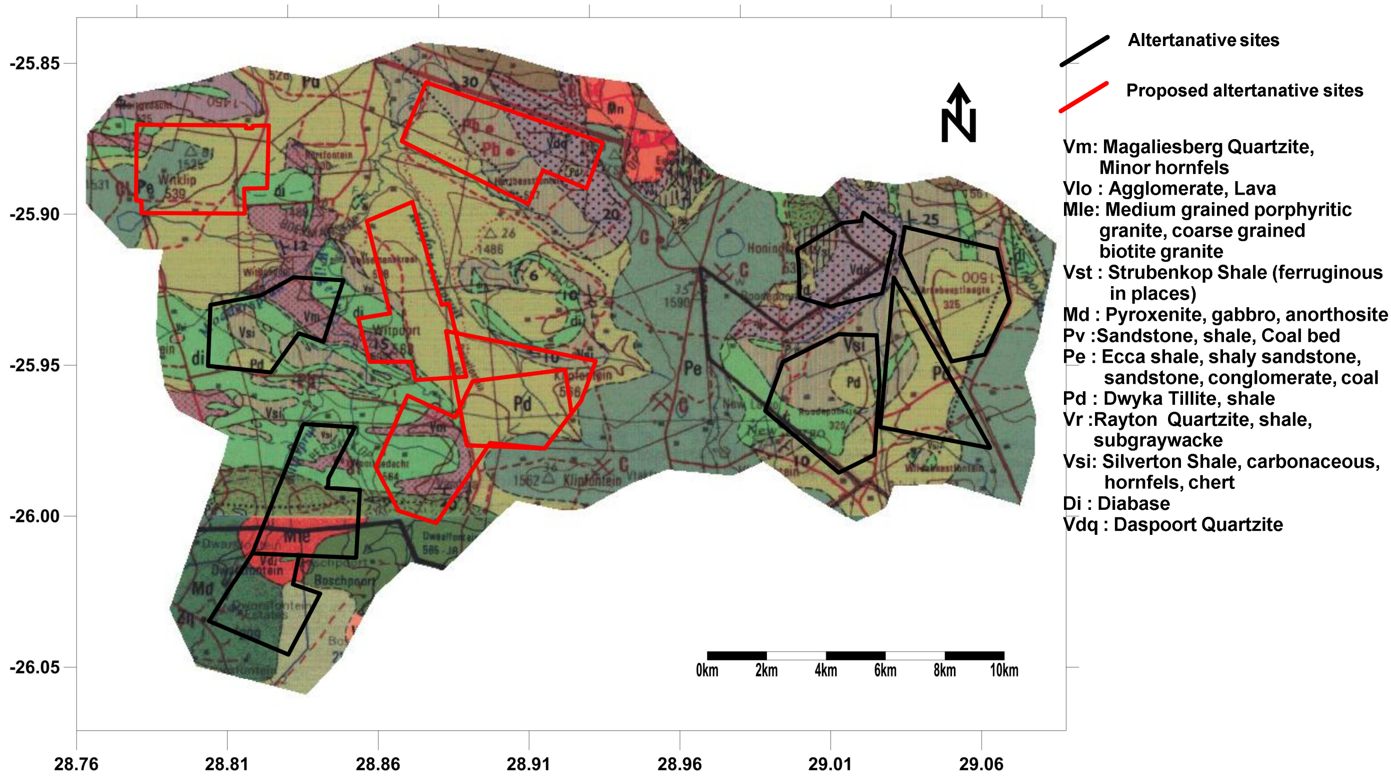

Figure 8-0-1. Underlying geology of the Kusile Power Station study area (Source: Aqua Earth Consultants 2013)

Surface Hydrology

The study area is located within the upper Olifants catchment in the Olifants WMA. The study area is situated primarily in the upper reaches of quaternary catchments B20F, which is drained by the Wilge River, and B20D, drained by the Bronkhorstspruit. Site alternative B straddles the two catchments, with two unnamed tributaries draining eastwards into the Wilge River and two tributaries draining northwards into the Bronkhorstspruit. Tributaries associated with all other site alternatives drain westwards into the Wilge River. Most tributaries are unnamed, except for the Klipfonteinspruit, which receives runoff from the Kusile Power Station, and the Holspruit, which drains site A.

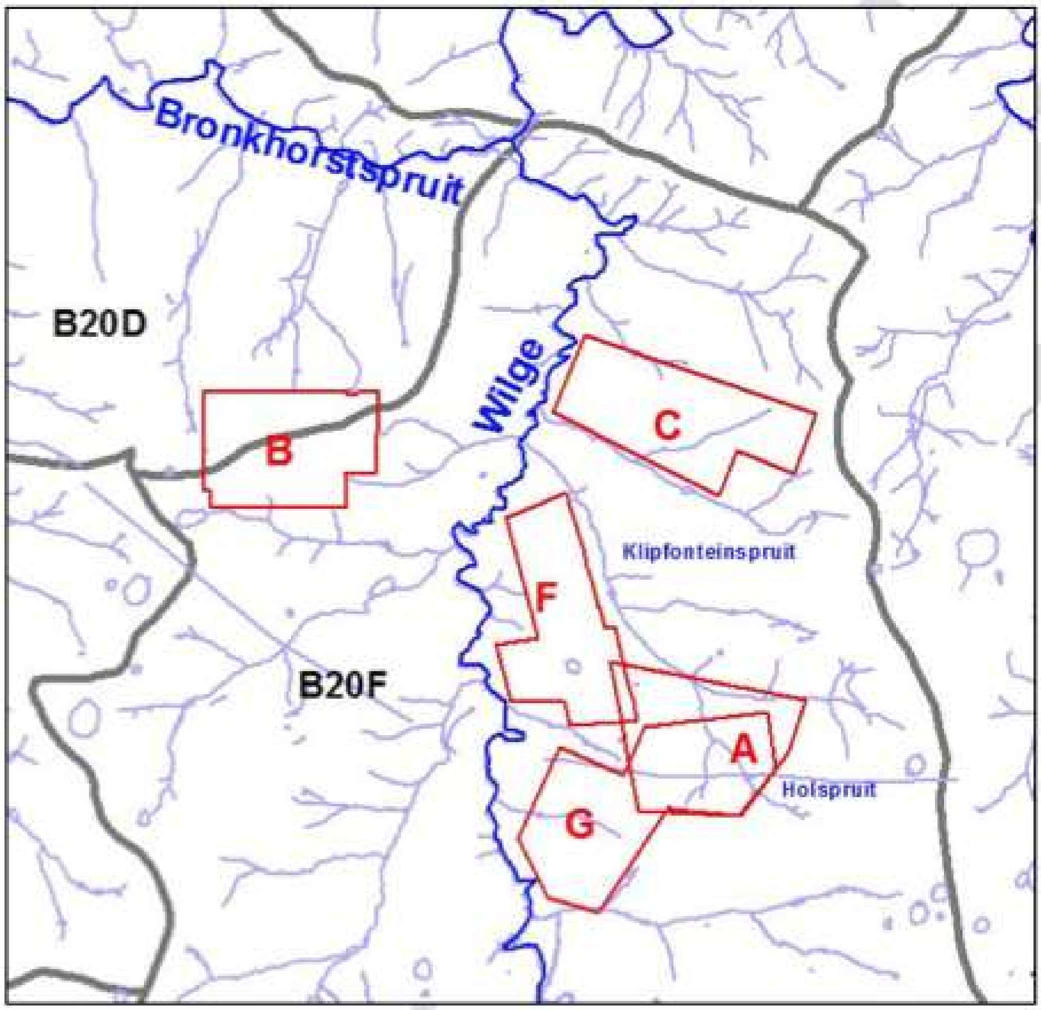

Figure 0-2. Location of the Wilge River and associated tributaries in the Kusile Power Station study area (Source: WCS 2013)

Wetlands

The recently published Atlas of Freshwater Ecosystem Priority Areas in South Africa (Nel *et al*, 2011) identified 791 wetland ecosystem types in South Africa based on classification of surrounding vegetation (taken from Mucina and Rutherford, 2006) and hydro-geomorphic (HGM) wetland type. Seven HGM wetland types are recognised and 133 wetland vegetation groups. Based on this classification, the following wetland vegetation types are indicated as occurring in the study area:

Table 0-1. Summarised findings of the wetland ecosystem threat status assessment as undertaken by the National Biodiversity Assessment 2011: Freshwater Component (Nel *et al.*, 2011) for wetland ecosystems recorded on site

Wetland Ecosystem Type	Wetland HGM Type (WT)	Threat Status of WT	Protection Level of WT	Wetland Vegetation Group (WVG)	Threat Status of WVG
Mesic Highveld Grassland Group 4 Floodplain wetland	Floodplain	CR	Zero Protection	Mesic Highveld Grassland	CR
Mesic Highveld Grassland Group 4 Seep	Seep	EN	Zero Protection	Mesic Highveld Grassland	CR
Mesic Highveld Grassland Group 4 Depression	Depression	CR	Hardly Protected	Mesic Highveld Grassland	CR
Mesic Highveld Grassland Group 4 Channelled Valley Bottom	Channelled Valley Bottom	CR	Hardly Protected	Mesic Highveld Grassland	CR
Mesic Highveld Grassland Group 4 Unchannelled Valley Bottom	hannelled Valley Bottom	CR	Zero Protection	Mesic Highveld Grassland	CR

CR = Critically Endangered, implying area of wetland ecosystem type in good (A or B) condition ≤ 20% of its original area

EN = indicates Endangered, area of wetland ecosystem type in good condition ≤ 35% of its original area

There are approximately 2 034 ha of wetlands distributed throughout the study area, which is approximately 17% of the total surface area (Table 0-2). The majority of these wetlands are hillslope seepage wetlands followed by channelled valley bottom wetlands. The distribution of the different wetland HGM types is given in Figure 0-3 below.

Table 0-2. Total area of wetland by hydro-geomorphic (HGM) type within the total Kusile Power Station Study Area

Wetland Type	Area (ha)	% Of wetland area	% Of study area
Channelled valley bottom	311,18	15,29%	2,61%
Floodplain	282,78	13,90%	2,37%
Hillslope seepage	1 371,78	67,42%	11,49%
Pan	16,45	0,81%	0,14%
Riparian Zone	5,57	0,27%	0,05%
Unchannelled valley bottom	7,17	0,35%	0,06%
Dams	39,75	1,95%	0,33%
TOTAL	**2 034,69**	**100,00%**	**17,05%**

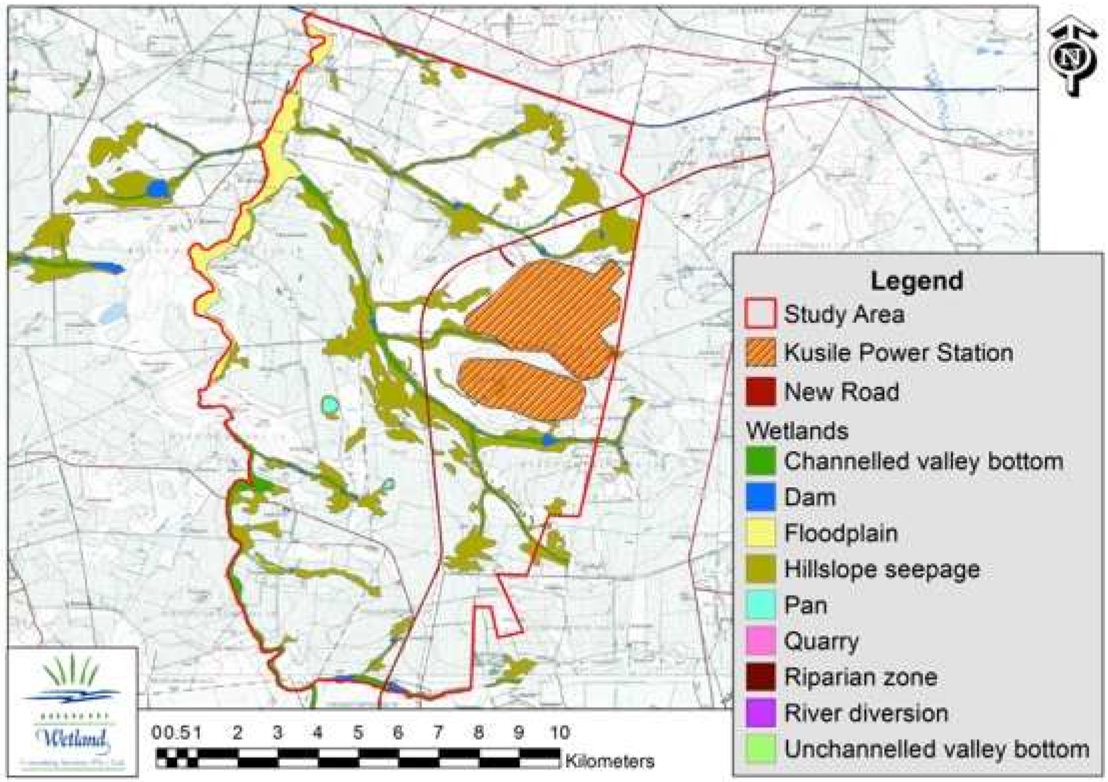

Figure 0-3. Distribution of wetland HGM types in the Kusile Power Station study area (Source: WCS 2013)

Terrestrial Ecosystems

This section is taken from the Terrestrial Ecosystems Assessment (2013) Report developed by Golder Associates.

The study area is located in the Eastern Highveld Grassland and Rand Highveld Grassland vegetation types of the grassland biome (Mucina & Rutherford, 2006). The associated environmental characteristics of the grassland biome in general and Eastern Highveld Grassland and Rand Highveld Grassland are discussed below.

Figure 0-4. Vegetation types found within the Kusile Power Station stud area as described by Mucina & Rutherford (2006) (Source: Golder 2013). The maroon background colour represents the Eastern Highveld Grassland and the beige background colour represents Rand Highveld Grassland vegetation types of the grassland biome

Grassland biome

The grassland biome covers approximately 28% of South Africa and is the dominant biome on the central plateau and inland areas of the eastern subcontinent (Manning, 2009). Grasslands are typically situated in moist, summer rainfall regions, which experience between 400 mm and 2000 mm of rainfall per year. Vegetation consists of a dominant ground layer comprising grass and herbaceous perennials with little to no woody plant species present. According to Tainton (1999) the study area falls within 'fire climax grassland of potential savanna'. As this description suggests, these areas would probably succeed to savanna (co-dominance of woody and grass species) but are maintained in a grassland state by frequent fire.

Eastern Highveld Grassland

A broad band of Eastern Highveld Grassland extends to the south of Rand Highveld Grassland from Johannesburg in the east through to Bethel, Ermelo and Piet Retief in the west. This vegetation is dominated by elements of Acocks's (1953) Bakenveld and the North-Eastern Sandy Highveld and Moist Sand Highveld Grassland of Low & Robelo's (1996). Approximately 1 214 467 ha of Mpumalanga was originally covered by Eastern Highveld Grassland (Ferrar & Lötter 2007). The following notes sourced from Mucina & Rutherford (2006) summarise the characteristics of this vegetation type:

Vegetation and Landscape features

Eastern Highveld Grassland found on slightly to moderately undulating plains, low hills and wetland depressions. Grasses are typical Highveld species from the genera *Aristida*, Digitaria, *Eragrostis,* and *Tristachya*. Woody species are commonly found in rocky areas and include *Acacia caffra, Celtis africana, Protea caffra, Protea welwitschii, Diospyros lycioides* and *Rhus magalismontana* (Mucina & Rutherford, 2006).

Important Plant Taxa

Based on Mucina & Rutherford's (2006) vegetation classification, important plant taxa are those species that have a high abundance, a frequent occurrence (not being particularly abundant) or are prominent in the landscape within a particular vegetation type. They note the following species are important taxa in the Eastern Highveld Grassland vegetation type:

Shrubs: *Anthospermum rigidum* and *Stoebe plumosa.*
Graminiodes: *Aristida aequiglumis, Aristida congesta, Aristida junciformis, Cynodon dactylon, Digitaria monodactyla, Eragrostis chloromelas, Eragrostis curvula, Eragrostis plana, Eragrostis racemosa, Heteropogon contortus, Loudetia simplex, Setaria sphacelata, Sporobolus africanus, Themeda triandra, Alloteropsis semialata* and *Monocymbium ceresiiforme, inter alia.*
Herbs: *Berkheya setifera, Haplocarpha scaposa, Euryops gilfillanii, Euryops transvaalensis, Justicia anagalloides, Acalypha angusta, Chamaecrista mimosoides, Dicoma anomala, Kohautia amatymbica, Lactuca inermis, Gladiolus crassifolius, Haemanthus humilis* and *Selago densiflora.*
Endemic Taxon: The geophytic herbs *Agapanthus inapertus*, *Eucomis vandermerwei* and the succulent herb *Huernia insigniflora* are endemic to this region.

Conservation

Mucina & Rutherford (2006) classify Eastern Highveld Grassland at a regional scale as Endangered. According to Ferrar & Lötter (2007) within Mpumalanga this vegetation type has an ecological status of Endangered-high. Only a small fraction is currently conserved in statutory reserves such as Nooitgedacht Dam and Jericho Dam Nature Reserves. Approximately 44% of the Eastern Highveld Grassland has already been transformed by cultivation, plantations, mines and urbanisation. Erosion of this vegetation type is low (Mucina & Rutherford, 2006).

Rand Highveld Grassland

Rand Highveld Grassland extends in an east-west band from Stoffberg in Mpumalanga to the outskirts of Pretoria in Gauteng. This vegetation is dominated by elements of Acocks's (1953) Bakenveld and Low & Robelo's (1996) Rocky Highveld Grassland and Moist Sandy Highveld Grassland. According to Ferrar & Lötter (2007) this vegetation type originally covered 589 365 ha of Mpumalanga Province.

Vegetation and Landscape features

Rand Highveld Grassland is a highly variable landscape comprising elevated slopes and ridges and undulating grass plains. Vegetation ranges from species-rich sour grassland to sour shrub-land. Common taxa include grass species from the genera *Themeda, Eragrostis, Heteropogon* and *Elionurus* and herbs belonging to *Asteraceae*. Rocky areas are dominated by open woodlands of *Protea caffra, Protea welwitschii*, *Acacia caffra, Celtis africana* and *Searsia magalismontana* (Mucina & Rutherford, 2006).

Important Plant Taxa

Based on Mucina & Rutherford's (2006) vegetation classification, important plant taxa are those species that have a high abundance, a frequent occurrence (not being particularly abundant) or are prominent in the landscape within a particular vegetation type. They note the following species are important taxa in the Rand Highveld Grassland vegetation type:

Shrubs: *Anthospermum rigidum, Indigofera comosa, Rhus magalismontana* and *Stoebe plumose.*
Graminiodes: *Ctenium concinnum, Cynodon dactylon, Digitaria monodactyla, Diheteropogon amplectens, Eragrostis chloromelas, Heteropogon contortus, Loudetia simplex, Themeda triandra, Aristida aequiglumis, Aristida congesta* and *Monocymbium ceresiiforme, inter alia.*
Herbs: *Acanthospermum australe, Justicia anagalloides*, *Acalypha angusta, Chaemecrista mimosoides, Dicoma anomala, Kohautia amatymbica, Lactuca inermis* and *Selago densiflora.*
Endemic Taxon: The geophytic herbs *Agapanthus inapertus*, *Eucomis vandermaerwei* and the succulent herb *Huernia insigniflora* are endemic to this region.

Conservation

Based on Mucina & Rutherford (2006), regionally Rand Highveld Grassland is classified as Endangered. Within Mpumalanga, Ferrar & Lötter (2007) categorise Rand Highveld Grassland as having an ecological status of Endangered-low.

Although the target for conservation is 24%, only 1% of this vegetation type is currently under statutory conservation in reserves such as Kwaggavoetpad, Van Riebeck Park and Boskop Dam Nature Reserves. Cultivation, plantations and urbanisation have resulted in the transformation of large parts of Rand Highveld Grassland. Exotic invasive plants, particularly *Acacia mearnsii* are present. Only about 7% of this vegetation type has been subject to moderate to high erosion (Mucina & Rutherford, 2006).

Socio-economic Systems

Overview[2]

The study area is situated in the Olifants Water Management Area (WMA). The Olifants WMA is commonly divided into three management sub-areas; the Upper Olifants, Middle Olifants and Steelpoort, Lower Olifants sub-areas:

[2] Unless otherwise referenced, the discussion in this section and proceedings sections were sourced from the Olifants Water Resource Classification study: economic assessment (www.dwa.gov.za)

- Upper Olifants sub-area (within which the Kusile Power Station site is located) constitutes the catchment of the Olifants River down to Loskop Dam.
- Middle Olifants sub-area comprises the catchment of the Olifants River downstream from the Loskop Dam to the confluence with the Steelpoort River.
- Lower Olifants management zone represents the catchment of the Olifants River between the Steelpoort confluence and the Mozambique border.

The Olifants River originates near Bethal in the Highveld of Mpumalanga. The river initially flows northwards before curving in an easterly direction through the Kruger National Park and into Mozambique where it joins the Limpopo River before discharging into the Indian Ocean.

The main tributaries are the Wilge, Elands and Ga-Selati Rivers on the left bank and the Steelpoort, Blyde, Klaserie and Timbavati Rivers on the right bank. The Olifants River is shared by South Africa, Botswana, Zimbabwe and Mozambique (DWA 2011).

Formal economic activity in the WMA is highly diverse and is characterised by commercial and subsistence agriculture (both irrigated and rain fed), diverse mining activities, manufacturing, commerce and tourism. Large coal deposits are found in the Emalahleni and Middelburg areas (Upper Olifants) and large platinum group metal (PGM) deposits are found in the Steelpoort, Polokwane and Phalaborwa areas. The WMA is home to several existing large thermal power stations, which provide energy to large portions of the country. Extensive agriculture can be found in the Loskop Dam area, the lower catchment near the confluence of the Blyde and Oilfants Rivers as well as the in the Steelpoort Valley and the upper Selati catchment.

A large informal economy exists in the Middle Olifants, with many resource-poor farmers dependent upon ecosystem services.

The area has many important tourist destinations, including the Blyde River Canyon and the Kruger National Park.

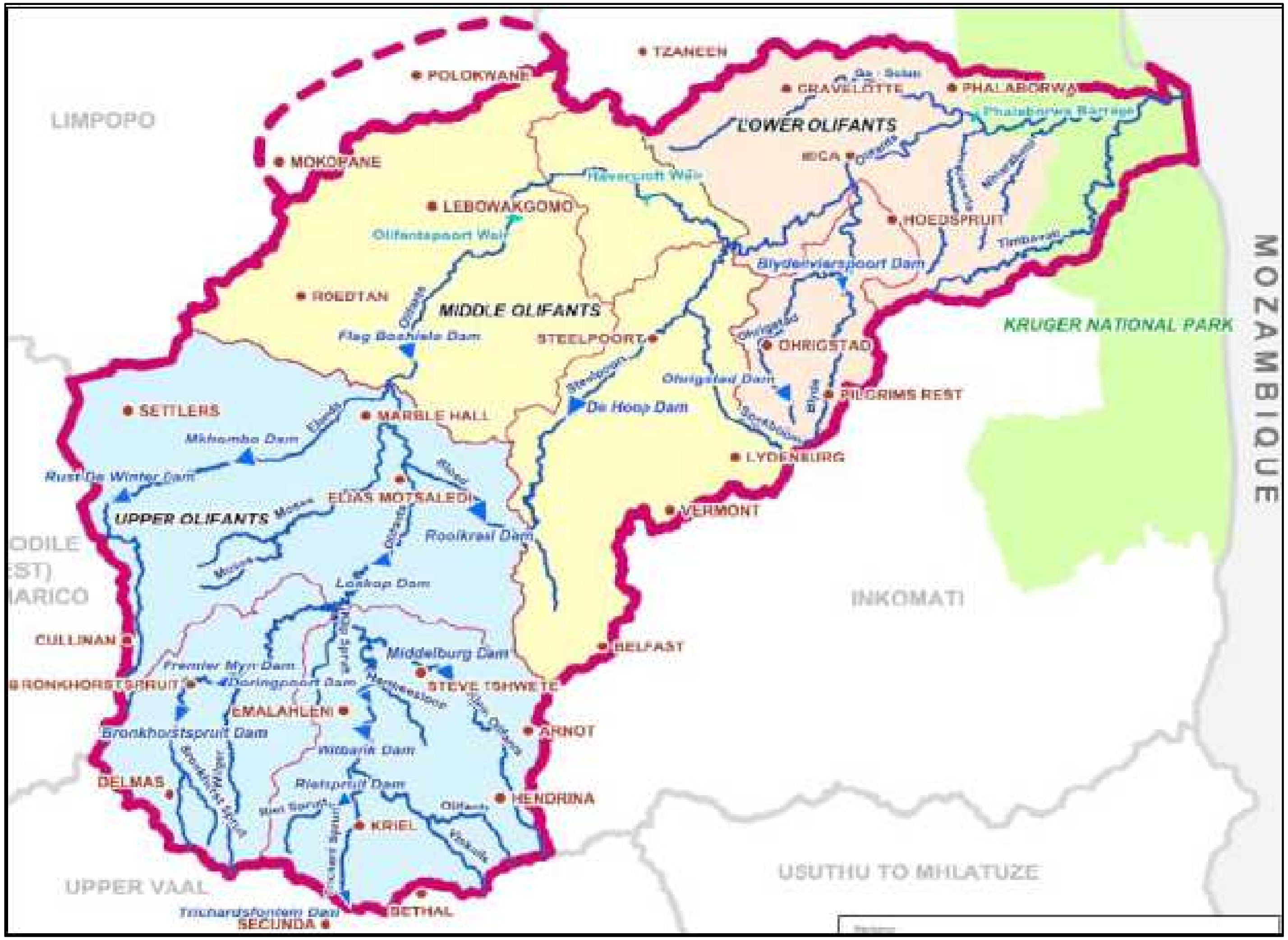

Figure 0-5. The Olifants Water Management Area (Source: DWA 2012)

Land Use

Land use in the Olifants WMA is diverse and consists of irrigated and dryland cultivation, improved and unimproved grazing, mining, industry, forestry and urban and rural settlements. A breakdown of land use and land cover is given in Table 0-3. Figure 0-6 is a map of land-use within the catchment based on land cover estimates derived from high-resolution satellite imagery published by the South African National Land Cover Project (CSIR, 2003).

Table 0-3. Land use and land cover in the Olifants Water Management Area (Source: CSIR 2003)

Land Use	Area (ha)	%
Natural vegetation	3 474 159	63.69%
Grazing	1 689	0.03%
Plantations	64 347	1.18%
Wetlands & Water	56 422	1.03%
Degraded	552 267	10.12%
Permanent commercial cultivation	18 126	0.33%
Temporary commercial cultivation	828 495	15.19%
Subsistence cultivation	244 989	4.49%
Urban (formal residential)	110 820	2.03%
Urban (informal residential)	47 509	0.87%
Urban (smallholdings)	6 841	0.13%
Urban (commercial)	1 524	0.03%
Urban (industrial)	5 247	0.10%
Subsurface mining	26	0.00%
Surface mining	36 618	0.67%
Mine tailings	5 693	0.10%
Total	**5 454 772**	

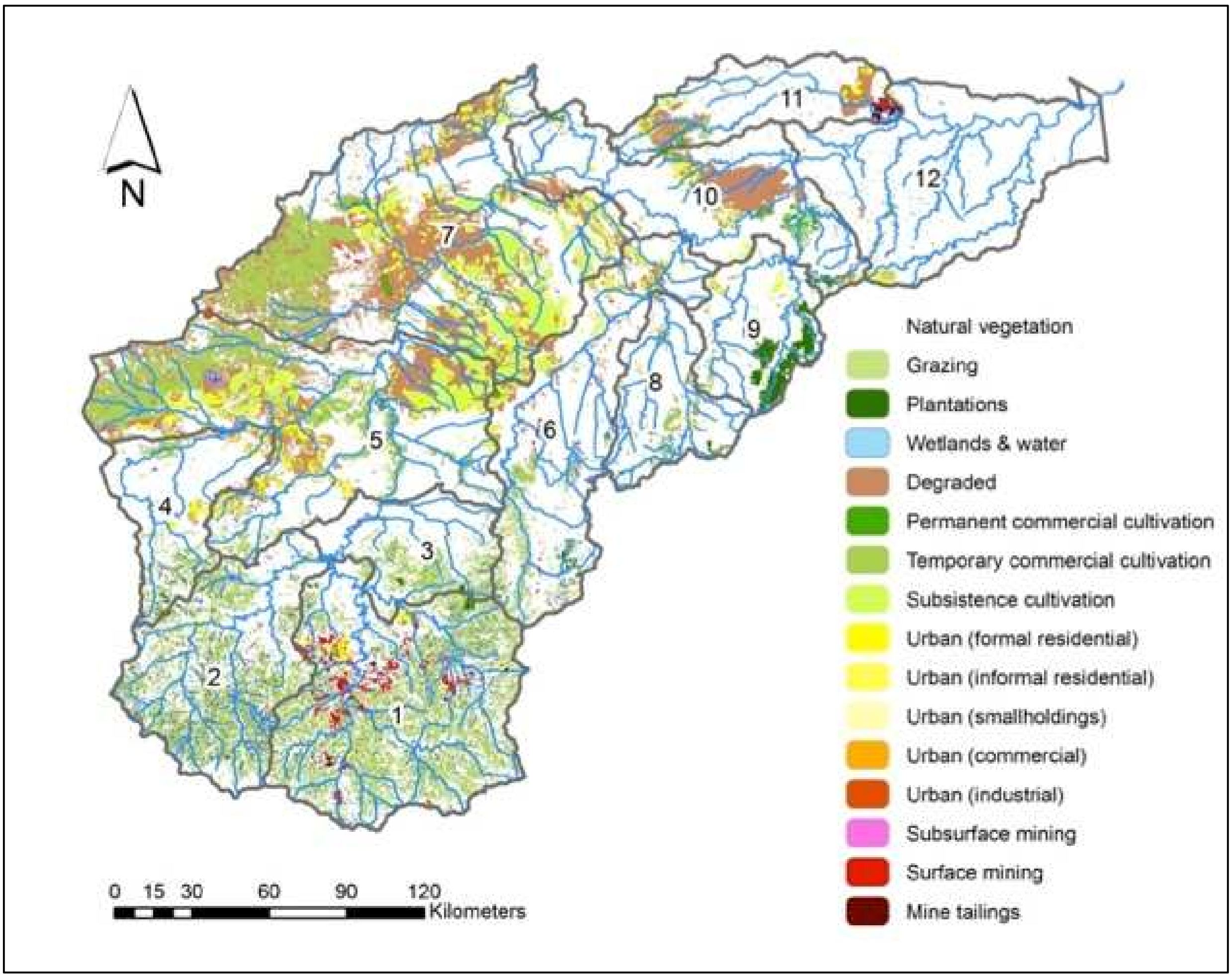

Figure 0-6. Land use map of the Olifants WMA (all land classes) (source: South African National Land-Cover database, CSIR, 2003)

Agriculture

Agriculture in the Olifants WMA can be broadly divided into three farming types:

- Resource-poor farming activities (both dry land and irrigated),
- Commercial dry land, and
- Commercial irrigated farming (IWRM 2008).

Maize is the dominant dryland crop grown throughout the catchment while commercial irrigated farming is highly diversified with wheat, maize and cotton comprising the bulk of the irrigated crop. A large portion of high value crops for export, such as citrus and grapes, are grown in the catchment especially around the Groblersdal and Marble Hall areas (IWRM 2008).

The Olifants Reconciliation Strategy Report (DWA 2011) estimated irrigation agriculture land to comprise 88,772 ha. Irrigation takes place both on irrigation schemes and as run-of-river irrigation (or diffuse irrigation). Irrigation is the largest water user in the Olifants River catchment, with the two largest schemes situated downstream of the Loskop and Blyderivierspoort Dams. Of this 39,378 ha are on irrigation schemes at high assurance of supply (80%) and 49,394 ha are diffuse irrigation at lower assurances of supply.

The total output of agriculture (dryland and irrigation) in the study area is estimated at R7.48 billion in 2010. Of this, R2.86 billion contributed to Gross Domestic Product (GDP).

Mining

Various mining activities span the Olifants River Basin. Three major concentrations of mining activities are of importance:

- Coal mining on the Mpumalanga Highveld;
- Platinum Group Metals (PGM) in the Middle Olifants and Steelpoort Valley; and
- Various mining activities around the Phalaborwa Industrial Complex and Gravelotte.

Mining within the Upper Olifants sub-catchment consists almost entirely of coal mining. Coal mining activities are extensive. The coal mining activities supply coal to the various power stations in the WMA, to industrial users and to the export market.

Much of the Upper Olifants falls within the Witbank Coalfield, where most of South Africa's coal is mined.

Within the Olifants WMA, there are five major coal companies (BHP Billiton, Anglo Coal, Xstrata, Exxaro and Optimum Coal) that produce the bulk of coal in South Africa. In addition there are a host of other smaller coal companies that produce coal, but information on their activities is limited. Listed companies produce 81% of coal production in South Africa (Chamber of Mines Facts and Figures 2011 and Company Annual Reports), with the balance of coal produced by smaller mining companies.

The total coal production in the Olifants WMA was 121.4 Mt in 2010, which was about 47% of the total coal produced in SA for 2010. The total output of coal mining was approximately R52.8 billion. Of this, R35.8 billion contributed to GDP.

Platinum mining dominates mining activities in the Middle Olifants zone. The Bushveld Igneous Complex (BIC) is the world's largest and most valuable layered intrusion. It holds over half the world's platinum, chromium, vanadium and refractory minerals and has ore reserves that could last for hundreds of years. These also include significant reserves of tin, fluorite and copper. Platinum group metals (as well as vanadium, chrome and iron) have been initiated in the Steelpoort/Mogoto and Mokopane areas, and is dependent upon sufficient water resources available.

The majority of platinum mining in the Olifants WMA is situated in the Steelpoort and Middle Olifants zones. The Blue Ridge Platinum Mine (operated by Aquarius) is situated 15km from Groblersdal and produces 35 000 oz. of platinum annually. There are three major platinum mining operators present

(Amplats, Impala Platinum and Aquarius) in the Steelpoort zone, while other, smaller mining companies are present, information regarding their operation is however limited. The Marula Platinum Mine (operated by Impala Platinum) is situated north east of Burgersfort and produces 70 000 oz. of platinum annually.

The Olifants WUA produced approximately 1,764,000 oz. of PGM in 2010. The total output of PGM mining was approximately R15.4 billion in 2010. Of this, R7.0 billion contributed to GDP.

In the Lower Olifants, Intensive copper and phosphate mining operations exist around Phalaborwa. The mineral rich Phalaborwa complex was intruded at the same time as the Bushveld Complex.

The Phalaborwa Mining Company (operated by Rio Tinto) is South Africa's largest copper producer and in addition also produces titaniferous magnetite, nickel, uranium, gold, silver, rare-earth elements, phosphates and vermiculite. The operation encompasses a copper mine, smelter and refinery and produces approximately 80,000 tonnes of refined copper annually.

Foskor is a large producer of phosphate and zirconium as well as small quantities of copper, PGMs and other minerals.

The Cullinan Diamond mine, owned by Petra Diamonds, is situated at Cullinan, on the border of the WMA.

Samancor operates the Eastern Chrome Mine situated close to Steelpoort. The mine consists of three underground mines, two opencast mines, four surface beneficiation plants and two tailings re-treatment plants, typically producing around 2.0 Mt of saleable product per annum.

Other operations include the Consolidated Murchison Mine, which produces antimony and gold found near Mica and the mining of mica in the greater Gravelotte and Mica areas.

Xstrata Alloys operate both the Thornecliffe and Helena Chrome Mines near Steelpoort. The mines annual production capacity is 1,440kt and 600kt respectively.

Evraz Highveld Steel operates the Mapochs Mine near Roossenekal. The mine is an open-cast mining operation which produces lump iron ore and ore fines.

To the west of Phalaborwa, rocks of the Gravelotte Group and Rooiwater Complex outcrop in the vicinity of the town of Gravelotte. Quartzite, schists, basic lava and granitic rocks dominate the Gravelotte Group lithology. These formations contain important deposits of antimony and gold, with minor deposits of mercury and zinc. An extensive deposit of heavy mineral sands (illmenite, rutile and zirconium) is located near the town of Gravelotte.

These mining activities within the Olifants WUA produced a total output of approximately R11.1 billion in 2010. Of this, R5.7 billion contributed to GDP. This analysis was based on a summary of the annual reports of mining companies in the study area.

Water and Electricity

Eskom has 11 coal-fired power stations in South Africa and 8 of these stations are found in the Olifants WMA (the 8th, Kusile, is still under construction). The Kusile Power Station is one of two (the other is Medupi Power Station in Limpopo Province) new thermal power stations currently being built by Eskom. Kusile will have an installed capacity of 4,800 MW, making it one of the largest thermal power stations in the world. These 8 stations will produce approximately 70% of South Africa's coal-fired electricity.

Power generation contributed approximately R6.7 billion to Gross Domestic Product. The water sector contributed approximately R1.3 billion to GDP (Eskom Annual Report 2010/11).

Table 0-4. Installed capacity of thermal power stations in the Olifants WMA

Power Station	Installed Capacity (MW)
Arnot	2,100
Duvha	3,600
Hendrina	2,000
Kriel	3,000
Komati	1,000
Matla	3,600
Kendal	4,116
Kusile (Under construction)	4,800
Total	**24,216**

Manufacturing

Several large manufacturing facilities, associated with the mining industry, exist in the study area. Samancor operates the Tubatse Ferrochrome Plant situated in Steelpoort. Xstrata Alloys' Lion Ferrochrome Operation is also located near Steelpoort. The annual production capacity of the plant is approximately 360kt. Xstrata Alloys also operates the Lydenburg Ferrochrome plant near the town of Mashishing. The Plant has the capacity to produce 396kt of Ferrochrome per annum. Evraz Highveld Steel is one of the largest manufacturing operations within the WMA. This steelworks, which is close to eMalahleni comprises the Iron Plant, the Steel Plant, the Flat Products and Structural Products Mills and operational support infrastructure. Samancor Chrome operates two chrome-smelting operations within IWUA being, Ferrometals near Emalahleni and Middelburg Ferrochrome near Middelburg. These activities within the Olifants WUA contributed approximately R2.4 billion to GDP in 2010. Other manufacturing activities contributed another R20.5 billion to GDP in 2010. (Source: DBSA Social Accounting Matrixes)

Tourism Economy

The Olifants WMA contains important natural heritage, especially in its lower reaches. These areas are water-dependent and play an important role in the tourism economy of the region. Some of these areas are closely associated with cultural heritage. Key areas include:

- The Kruger National Park and adjoining protected areas (Klaserie, Timbavati, Olifants Conservancy, Umbaba)
- The Wolkberg Wilderness Area on the northern rim of the Olifants catchment;
- The Legalametse Nature Reserve south east of the Wolkberg; and
- The Loskop Dam Nature Reserve.

Dullstroom and Lydenburg and up to the Steelpoort River and Burgersfort in the north is another important tourism area, with natural beauty and as well as being a premier fly-fishing destination.

The Kruger to Canyons Biosphere Reserve is an internationally recognised development initiative that complies with and is accredited to UNESCO's Man and the Biosphere programme. In such areas widely accepted principle of planning around a core-protected area, surrounded by areas where varying forms of conservation/utilisation take place, are applied. Also in the Olifants WMA is an area that abuts onto the western boundary of the KNP. It lies between Acornhoek and Phalaborwa and is the largest area of privately owned conservation land in the world. The inclusion of the Timbavati, Balule, Klaserie, Umbabat and other private nature and game reserves has effectively added in excess of 250,000 ha (more than 10%) to the conservation area of the KNP (DWA 2005).

The economic benefits of the tourism industry are measured in a number of economic sectors, including the accommodation, transport and trade sectors.

Other Economic Sectors

Other economic sectors include all economic activities in the economic sectors. These sectors are defined according to the Standard Industrial Classification (SIC) used by Statistics South Africa and the Development Bank of Southern Africa (DBSA). Social Accounting Matrixes (SAMs) for the Mpumalanga and Limpopo Provinces represent the structure of these sectors within the regional economy and is available from the DBSA:

- Building and Construction
- Trade
- Accommodation
- Transport
- Communication
- Insurance
- Real Estate
- Business Services

- General Government Services
- Community, Social and Personal Services.

These sectors together contributed approximately R8.0 billion to GDP.

Summary

The total sectoral output per sector within the study area (Olifants WMA including the Polokwane-Mokopane zone) in 2010 is estimated as set out in Table 0-5 below. The contribution of these sectors to national GDP in 2010 is estimated at R129.6 billion.

Table 0-5. Summary of economic output and contribution to GDP by the key economic sector groups in the study area (2010)

Sector	Output (R'million)	GDP contribution (R'million)
Agriculture	7,488	2,859
Mining	92,844	54,033
Manufacturing	86,550	22,948
Water and Electricity	19,840	8,026
Other sectors	177,216	41,707

Economic Development and Water Use

The development of the Olifants WMA economy is to a large extent, dependent upon the agricultural and mining sectors. South Africa's National Development Plan (2011) identifies South Africa's mineral wealth as a key driver of economic development and also identifies the Agriculture sector as the key sector for developing and inclusive rural economy. Both these sectors, and their respective value chains, are dependent on water as an input into production.

Economic production activities use water as an input into their production processes. Production outputs are the gross income or turnover of each user activity. The Agriculture, Mining, Electricity and Water, and other sectors are all significant value adding sectors, with significant multiplier effects into the rest of the economy. The GDP of economic sectors directly dependent upon Water Use Licenses in the Olifants WUA in 2010 was R72 billion. This was 55% of the WUA GDP.

Thus, more than 50% of the GDP produced in the Olifants WMA are dependent upon water use licences.

The DWA Olifants Reconciliation Strategy Report (DWA 2011) describes the water use in the Olifants WMA (Table 0-6).

Diverse economic activities drive increasing demand for water in the Olifants WMA. These activities include power generation, mining, urban development, improved service delivery to rural communities, and irrigation. The Olifants WMA supplies water to Polokwane (Levuvu-Letaba WMA) for urban consumption and will likely in future also supply Mokopane (Levuvu-Letaba WMA) from the Flag Boshielo Dam, for PGM mining consumption.

The water balance for the Olifants River catchment as a whole indicates a small surplus in 2010, but a deficit from 2016. The future demand for water by mining and rural communities precipitated the De Hoop Dam development, due for commissioning in 2012. However, the DWA Olifants Reconciliation Strategy Report finds that even the additional yield provided by the De Hoop Dam and the raised Flag Boshielo Dam, will not be sufficient to supply future demand.

Table 0-6. Summary of water requirements (units: million m^3/year) (DWA 2011)

Sub-area	Irrigation	Urban	Rural	Industrial	Mining	Power Generation	Total
Upper	249	93	4	9	26	228	609
Middle	81	56	22	0	28	0	187
Lower	156	29	3	0	32	0	220
Total	**486**	**178**	**29**	**9**	**86**	**228**	**1016**

Irrigation is the largest consumer of water within WMA. The total irrigated area in the Olifants River catchment is 88,772 ha requiring 486 million m^3 per year. Of this, 39,378 ha form part of irrigation schemes, while the remainder are defined as diffuse schemes irrigation.

Urban water demand encompasses industrial, commercial, institutional and municipal use. The total water use by in the urban areas is 178 million m^3/a.

Rural water demand encompasses all domestic water requirements outside of urban areas and includes stock watering and subsistence irrigation on small rural garden plots. Rural water use comprises 29 million m^3/a.

Mining activities are dominated by coal mining, particularly in the Highveld, and PGM, but also include copper, gold, tin, platinum, phosphate and diamonds in the Lowveld. The mines use water for the processing of ores. The number of active mines in the catchment was estimated to be 93 (South African Council of Geoscience cited in DWAF 2003b). Coal mines source the bulk of their water from their underground operations and from own dams. The Phalaborwa Barrage on the Olifants River, supplemented from the Blyderivierpoort Dam and the Groot Letaba River, supply the water requirements to mining activities around Phalaborwa.

Strategic water requirements are those reserved for Eskom for power generation. Power stations in the Upper Olifants zone uses 228 million m^3/a for cooling purposes, supplied from the upper Komati or the Vaal Systems. The new Kusile power station near Emalahleni will use a dry cooling process, which is more water efficient.

The DWA Olifants Reconciliation Strategy Report (2011) summarises future water use for 2016 and 2035. Future demand for irrigation, power generation and heavy industrial use are expected to remain stable. Urban and Rural water requirements are expected to grow with population growth. The largest increase in water demand is expected within the Mining sector, and especially the PGM mining sector. The DWA Olifants Reconciliation Strategy Report proposes a range of water demand management and water supply augmentation measures for meeting all these future demands.

Table 0-7. Total high and low growth water requirements (DWA 2011)

Sector	**Current requirement (2010)**	**Future requirement (2035)**	
		High growth	**Low growth**
Irrigation	486	486	486
Urban	178	255	221
Rural	29	51	39
Industrial	9	9	9
Mining	86	140	128
Power Generation	228	229	229
TOTAL	**1,016**	**1,170**	**1,112**

Water quality

The Olifants River is presently one of the most threatened river systems in South Africa and reports of unexplained fish and crocodile deaths within the catchment, including in the Kruger National Park (KNP) have been made for several years. The water quality in the Olifants River has been deteriorating for many years as a result of industrial, mining and agriculture activities. The Water Research Commission has published a report on the state of water quality in the Olifants River, which describes the nature and extent of this problem (Heath *et. al.* 2010).