Application for Rectification i.t.o. Section 24G of the National Environmental Management Act of 1998 (as amended) for the Unlawful Commencement of Listed Activities for Underground Coal Gasification: Pilot Plant Phase 1, near Amersfoort, Mpumalanga

Draft

Eskom Holdings SOC Ltd

DEA Ref 14/12/16/3/3/1/54

October 2013

Eskom

Royal HaskoningDHV

Enhancing Society Together

DOCUMENT DESCRIPTION

Client:
Eskom Holdings SOC Ltd

Project Name:
Application for Rectification i.t.o. Section 24G of the National Environmental Management Act of 1998 (as amended) for the Unlawful Commencement of Listed Activities for Underground Coal Gasification Pilot Plant Phase 1, near Amersfoort, Mpumalanga

Royal HaskoningDHV Reference Number:
E02.JNB.000308

Authority Reference:
DEA Ref: 14/12/16/3/3/1/54

Compiled by:
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Date:
October 2013

Location:
Cape Town

Review & Approval:
Malcolm Roods

Signature

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

APPENDICES

GLOSSARY OF TERMS

Alternatives	Different means of meeting the general purpose and requirements of the activity, which may include site or location alternatives; alternatives to the type of activity being undertaken; the design or layout of the activity; the technology to be used in the activity and the operational aspects of the activity.
Aquifer	A geologic formation of porous rock, often sandstone that stores water. An aquifer may yield significant quantities of water to wells and springs and this water is often utilized as a primary source for municipal, industrial, irrigation and other uses.
Calorific Value	The quantity of heat that can be liberated from one kilogram of coal.
Coal	A solid, brittle, more or less distinctly stratified combustible carbonaceous rock formed by partial to complete decomposition of vegetation; varies in colour from dark brown to black; not fusible without decomposition and very insoluble.
Coal Gasification	The conversion of coal into a gaseous fuel.
Combustion	Burning coal with O_2 to make CO_2 and heat.
Combustion chamber	The part of a gasifier in which coal is oxidised.
Condensate	The liquid product that condensates from the raw gas when initially cooled and contains mainly water with water soluble hydrocarbons and solids of tar and ash.
Core sample	A cylinder sample generally 1-5" in diameter drilled out of an area to determine the geologic and chemical analysis of the overburden and coal.
Cumulative impact	The impact of an activity that in itself may not be significant but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area.
Depth	The word alone generally denotes vertical depth below the surface. In the case of boreholes it may mean the distance reached from the beginning of the hole, the borehole depth.
Draw down	A lowering of a reservoir or a change in hydraulic head in an aquifer, typically due to pumping a well.

Do-nothing alternative	The ‗do-nothing' alternative is the option of not undertaking the proposed activity.
Environmental Impact Assessment (EIA)	In relation to an application to which scoping must be applied, means the process of collecting, organising, analysing, interpreting and communicating information that is relevant to the consideration of that application as defined in NEMA.
Extraction	The process of mining and removal of cal or ore from a mine.
Fault	A slip-surface between two portions of the earth's surface that have moved relative to each other. A fault is a failure surface and is evidence of severe earth stresses.
Gasification	Any of various processes by which coal is turned into low, medium, or high CV gases.
Gas turbine	The gas turbine (also called a combustion turbine) is a rotary engine that extracts energy from a flow of combustion gas.
Goaf	The term applied to that part of the mine from which the coal has been removed and the space more or less filled up with waste or overburden. Also, the loose waste in a mine.
Grey Water	Water containing gasification condensates.
Groundwater	Water in the ground that is in the zone of saturation from which wells, springs, and groundwater run-off are supplied.
Hydrology	The science encompassing the behaviour of water as it occurs in the atmosphere, on the surface of the ground, and underground.
Interested and Affected Party (I&AP)	Any person, group of persons or organisation interested in or affected by an activity; and any organ of state that may have jurisdiction over any aspect of the activity.
Overburden	Layers of soil and rock covering a coal seam. In surface mining operations, overburden is removed prior to mining using large equipment. When mining has been completed, it is either used to backfill the mined areas or is hauled to an external dumping and/or storage site.
Pollution Control Dam	Dam to control / manage and treat contaminated stormwater runoff prior to release into the environment (water resource).
Process Water Dam	Dam for storage of condensate recovered from the gas treatment plant and gas pipeline. Also referred to as the condensate dam or dirty water dam.
Public Participation Process	A process in which potential interested and affected parties are given an opportunity to comment on, or raise issues relevant to, specific matters.
Raw gas	The product gas of gasification containing all substances of the process.
Red Data Species	Species listed in terms of the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species, and/or in terms of the South African Red Data List. In terms of the South African Red Data List, species are categorised as being extinct, endangered, vulnerable, rare, indeterminate, insufficiently known or not threatened.
Seam	A stratum or bed of coal.
Subsidence	The gradual sinking, or sometimes abrupt collapse, of the rock and soil layers into an underground mine. Structures and surface features above the subsidence area can be affected.
Underground Coal Gasification	UCG is a process carried out on ―unminable" coal seams. These are coal seams that cannot be mined by using the conventional coal mining methods e.g. open cast or underground mining. UCG involves injecting steam and air (or oxygen) into a cavity created in an underground coal seam, to form a synthetic natural gas.

ACRONYMS

CCGT – Closed Cycle Gas Turbine

DEA – Department of Environmental Affairs

DMR – Department of Mineral Resources

DWA – Department of Water Affairs

EAP – Environmental Assessment Practitioner

EIA – Environmental Impact Assessment

EIAR – Environmental Impact Assessment Report

EMPr – Environmental Management Programme

ESS – Environmental Scoping Study

FEPA – Freshwater Ecological Priority Area

FGM – Focus Group Meeting

GTP – Gas Treatment Plant

GSDM – Gert Sibande District Municipality

GVA – Gross Value Added

I&AP – Interested and Affected Party

IWULA – Integrated Water Use License Application

IWWMP – Integrated Waste Water Management Plan

MDEDET – Mpumalanga Department of Economic Development, Environment and Tourism

NEM:AQA – National Environmental Management – Air Quality Act (No. 39 of 2004)

NEM:WA – National Environmental Management – Waste Act (No. 59 of 2008)

NEMA – National Environmental Management Act (No. 107 of 1998)

NGO – Non-Governmental Organisation

NHRA – National Heritage Resources Act (No. 25 of 1999)

OCGT – Open Cycle Gas Turbine

PKSLM – Pixley ka Seme Local Municipality

PPP – Public Participation Process

RWQOs – Water Quality Objectives

SAHRA – South African Heritage Resources Agency

SDF – Spatial Development Framework

UCG – Underground Coal Gasification

WMA – Water Management Area

1 INTRODUCTION

Eskom Holdings SOC Limited (Eskom) is mandated by the South African Government to ensure the provision of reliable and affordable power to South Africa. Eskom currently generates approximately 95% of the electricity used in South Africa. Electricity cannot be stored in large quantities and must be used as it is generated. Therefore, electricity must be generated in accordance with supply-demand requirements. In addition, increasing economic growth and social development within Southern Africa is placing a growing demand on energy supply. Coupled with the rapid advancement in community development, is the growing awareness of environmental impact, climate change and the need for sustainable development.

Eskom's core business is in the generation, transmission (transport), trading and retail of electricity. In terms of the Energy Policy of South Africa –*energy is the life-blood of development*". Therefore, the reliable provision of electricity by Eskom is critical for industrial development and related employment and sustainable development in South Africa.

Underground Coal Gasification (UCG), a process whereby coal is converted *in situ* into combustible gas that can be used for power generation, is one of the new clean coal technologies being developed for implementation by Eskom.

The technology has been through 11 years of intensive research by Eskom since 2001 to achieve a better understanding of the gasification process, and the nature of the gas produced.

In order to meet the fuel requirements for optimal power generation at the Majuba Power Station, Eskom proposes the use of synthetic gas or *syngas (*15,000 Nm^3/hr) produced by the UCG process as a supplementary fuel source within the boilers at the power station. The 15,000 Nm^3/hr plant will be scaled up to 70,000 Nm^3/hr and based on the outcomes of the 70000 Nm^3/hr plant, Eskom may investigate the option of a commercial size power plant based on UCG technology. This ongoing process is linked to the parallel EIA process and is being separately authorised.

The **Environmental Impact Study** at hand (i.e. the rectification document at hand) is for the **existing UCG project: Pilot Plant Phase 1 and associated infrastructure** on the farm Roodekopjes 67 HS (Portions 1, 2, 3 and remaining extent), Portions 17 and 21 of the farm Bergvliet 65HS and Portions 4 and 5 of the farm Rietfontein 66HS, in support of the co-firing of gas at the Majuba Power Station (**Appendix B**).

Note that the existing, already developed Pilot Plant Phase 1 is limited to only portions of the farm Roodekopjes.

The UCG site is located within the southern portions of Mpumalanga Province, near the town of Amersfoort and opposite the Eskom Majuba Power Station. The area falls within the local administrative boundaries of Pixley ka Seme Local Municipality and the Gert Sibande District Municipality.

Refer to **Table 1** overleaf which details the relevant project and site information.

Table 1: Project and Site Information

Name of Project applicant:	**Eskom Holdings SOC Ltd**		
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Position in company:	Majuba UCG Site Manager		
Registration number:	2002/01527/06		
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E-mail:	DuvenaLD@eskom.co.za	Fax:	086 664 1155
Environmental Assessment Practitioner (EAP):	**Royal HaskoningDHV (Pty) Ltd** (refer to **Table 6** for individual's details)		
Name of Landowner(s):	**Eskom Holdings SOC Ltd**		
Contact person(s):	Mr Jan Coetzee		
Postal address:	P O Box 1091, Johannesburg, 2000		
Telephone:	(011) 800 4591	Cell:	082 653 0763
E-mail:	CoetzeJe@eskom.co.za	Fax:	086 662 8343
Municipality in whose area of jurisdiction the activity falls:	**Pixley Ka Seme Local Municipality** *(a.k.a. Dr Pixley ka Isaka Seme)* Gert Sibande District Municipality Mpumalanga Province		
Contact person:	Mr S Shabalala		
Postal address:	Private Bag X9011, Volkrust, 2470		
Telephone		Cell:	
E-mail:	shabalalas@pixleykaseme.gov.za	Fax:	(017) 735 3004
Farm / Erf name & number (incl. portion):	Portions 1, 2, 3 and Remaining Extent of the farm Roodekopjes 67HS		

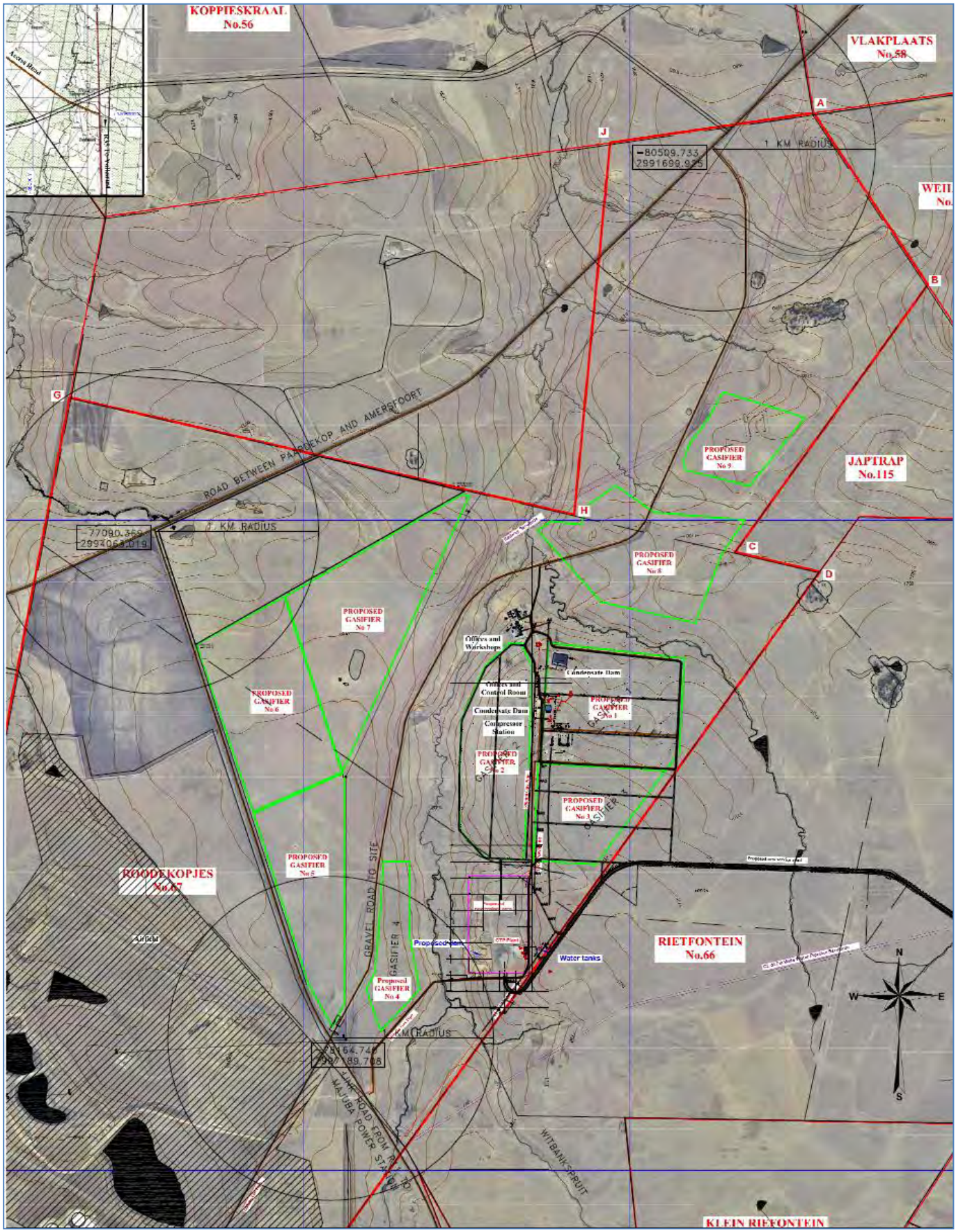


Figure 1: Locality map

1.1 Project Need and Justification

Eskom is committed to investigating and evaluating various options for the diversification of the energy mix over time (including renewable resources). As part of an ongoing effort to assess the viability / feasibility of all supply-side options, a number of power generation technologies, not yet implemented in South Africa on a commercial basis, are being evaluated in terms of technical, socio-economic and environmental aspects.

One such type of technology is Combined Cycle Gas Turbine (CCGT) power plant that uses gas from a Surface Coal Gasification process as a primary energy, which has been successfully proven to be commercially viable in other countries (e.g. China, Ukraine and Australia).

In the context of a primary energy supply option for utility scale power generation, the following characteristics of UCG technology are attractive from Eskom‘s perspective:

- UCG mining, in conjunction with a combined cycle gas turbine power station, is potentially a cleaner method of coal-based power generation. Once Eskom has proven commercial feasibility, the exact technology footprint will be compared to traditional coal power generation technologies.
- The UCG process at a commercial scale would likely create a large underground gas and heat storage inventory, making the gas supply very stable and consistent.
- Dependant on the area and coal resource, the cavity created by UCG could provide a suitable CO_2 sequestration option. This consideration is very embryonic, and will be explored by Eskom during further research.
- The commercial scale UCG production plant is essentially made up of a number of modular underground reactors with largely independent outputs. Thus, the coal extraction and overall gas output from the gasification process may be optimised by varying and then mixing the outputs of the individual modules.
- No ash or slag removal and handling are necessary as there is minimal particulate carry over in the gas, and most of the solids remain underground.
- The operating pressure of the underground gasifier is such that it maintains a negative hydraulic gradient into the cavity, thus preventing contamination of surrounding aquifers in the underground environment.
- Ground water influx into the gasifier creates an effective ~~-s~~team jacket” around the reactor making the heat loss *in situ* tolerably small.

South Africa has about 192 billion tons of coal reserves, of which 32 billion tons are viewed as economically extractable. UCG has the potential to extract coal resources previously regarded as either uneconomic or inaccessible due to depth, seam thickness, seam slope, seam fracturing and displacement, or other mining and safety considerations.

The ideal requirements for UCG are generally the opposite of the requirements for conventional underground mining, and hence UCG offers opportunity for expanding South Africa‘s mineable coal reserve base by extracting coal previously disregarded as being unminable. The Underground Coal Gasification concept therefore provides promising prospects for future energy supplies.

1.2 Project Background

Eskom commenced with UCG activities on the farm Roodekopjes 67HS in January 2007 as part of a phased development and implementation plan. The phased nature of the project enables Eskom to rigorously test the technology requirements and environmental effects of the UCG operations in South Africa.

1.2.1 Environmental Legal Status

Eskom has been granted the following authorisations for the exploration and testing phases of the UCG project:

- New Order prospecting right granted in 2005 (F/2005/03/11/0001) by the Department of Minerals and Energy (DME). Extension application lodged in November 2008.
- Exemption from conducting an EIA, in terms of Section 22 of the Environmental Conservation Act (Act No. 73 of 1989) was granted by the Mpumalanga Department of Agriculture and Land Administration in 2005, for the construction of a 7 km gas pipeline between the Majuba Coalfields and Majuba Power Station (Ref 17.2.1EV1).
- Exemption from the requirements of Sections 9 and 12 of the Atmospheric Pollution Prevention Act (Act No. 45 of 1965) granted by the Department of Environmental Affairs and Tourism in 2005 (Ref 23/4/2/1448). However, this exemption lapsed when the National Environmental Management: Air Quality Act (Act No. 39 of 2004) came into effect.
- Acceptance letter of the prospecting rights on 24 February 2009 (MP30/5/1/1/2/1144 PR) issued by the DME – now Department of Mineral Resources (DMR).
- Final Environmental Scoping Report for the 40 – 140MW Open Cycle Gas Turbine (OCGT) power plant was accepted by the Department of Environmental Affairs (DEA) in March 2010. *The EIA process initiated under the EIA Regulations (2006) has subsequently lapsed, hence the new integrated application for authorisation lodged in terms of the EIA Regulations (2010) and the NEM:WA (Act No. 59 of 2008).*
- A new mining right application has been lodged and accepted by the DMR for the farm Roodekopjes 67HS (Portions 1, 2, 3 and the remaining extent) – Ref 30/5/1/1/2/10031 MR.

During the planning process, the initial modus operandi was to co-fire at the Majuba Power Station with 15,000 Nm^3/hr of UCG syngas. This would then allow the Eskom engineering team to determine the characteristics of the gas (i.e. quality, quantity and stability) in order to drive a 40 – 140 MW Open Cycle Gas Turbine (OCGT) demonstration plant. This demonstration plant would have been the basis upon which a decision would be made for a 2,100 MW Combined Cycle Gas Turbine (CCGT) commercial power station.

From the gas production so far, the Eskom engineering team has come to the conclusion that the production of 15,000 Nm^3/hr of UCG syngas is not sufficient to determine the characteristics of the gas with sufficient accuracy to continue with the establishment of the 40 – 140 MW demonstration plant.

It has therefore been decided, to increase the gas production to 70,000 Nm^3/hr (parallel EIA process, Phase 1C, **Figure 3**) and maintain this level of production for at least 12 (twelve) months to accurately determine the gas characteristics. This increased gas volume will be disposed of through co-firing at the Majuba Power Station. This exercise is expected to be finalised in 2017 should all permits be in place to allow such to occur.

Once this exercise has been completed and the results evaluated by Eskom engineering team, a decision will be made on further commercial development.

To contextualise, the overall process can be considered according to the following diagram (**Figure 2**).

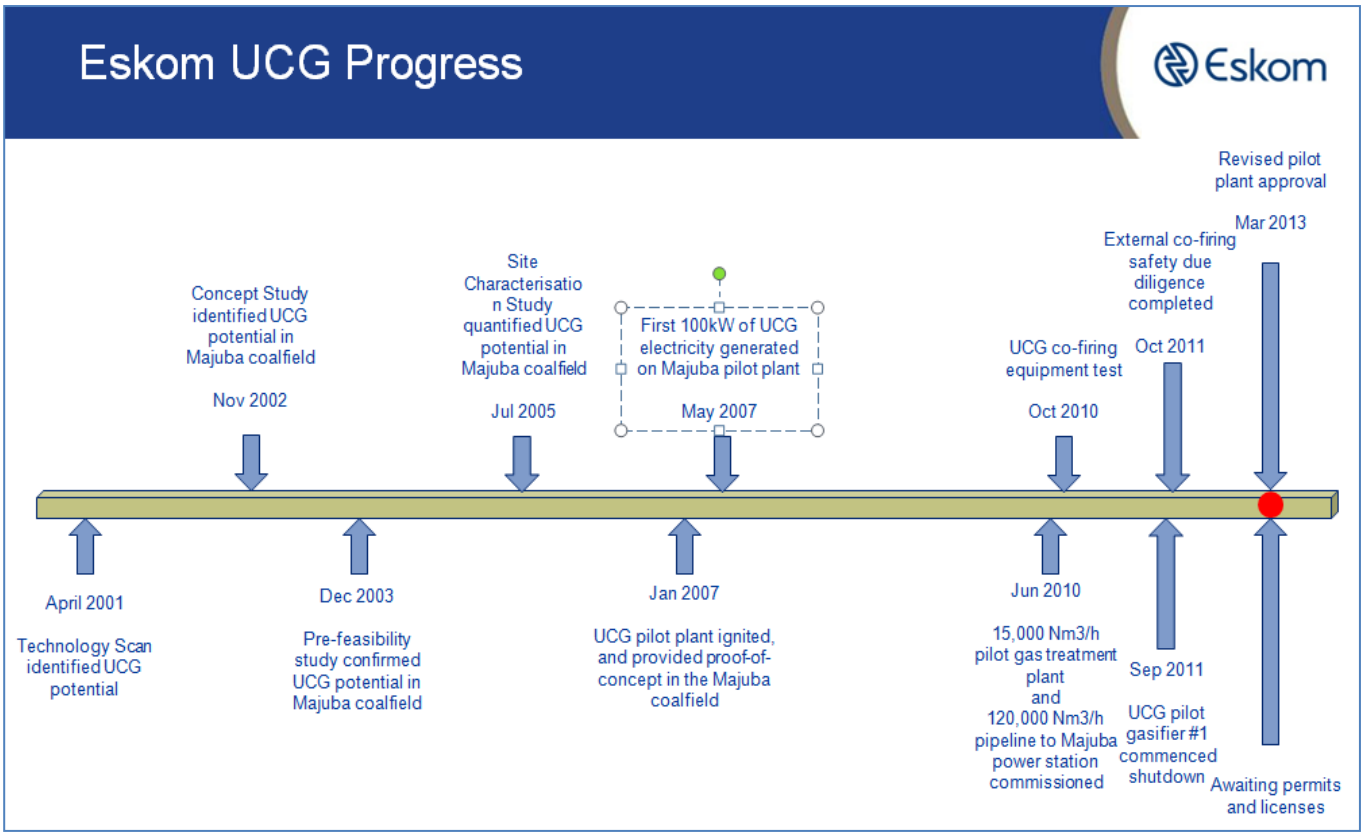


Figure 2: Timeline of the UCG process

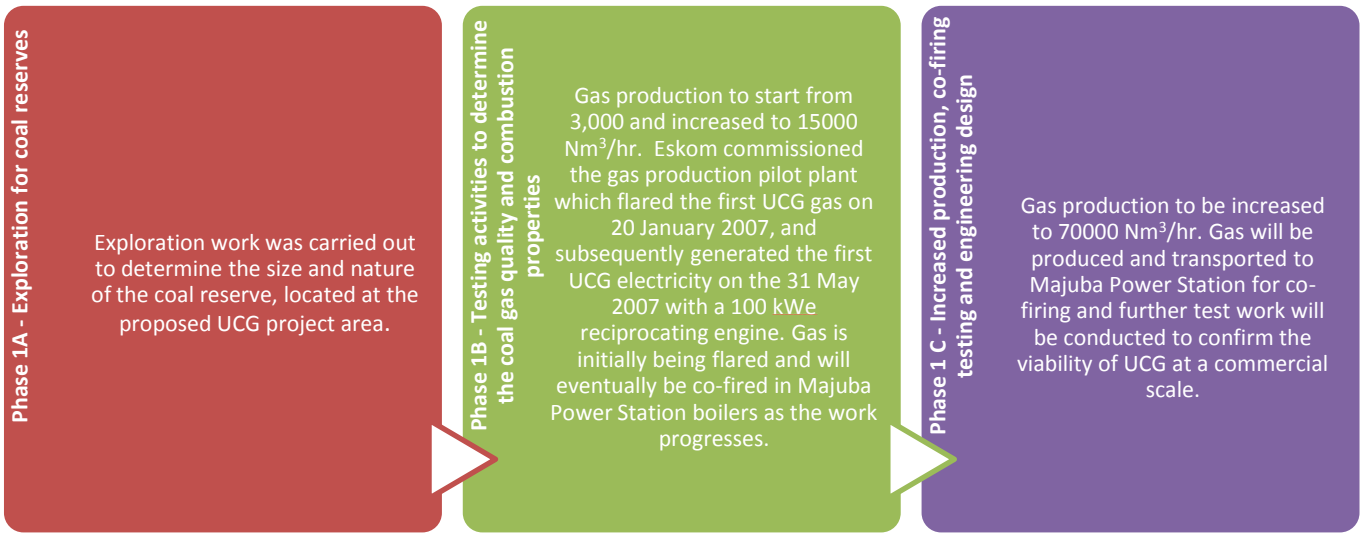


Figure 3: Phases in the UCG project process

Note that the upgrade / increase process is being considered in terms of the parallel EIA process and will only proceed once an environmental authorisation is obtained (either positive or negative) on the rectification process at hand.

1.2.2 Need for Rectification

The baseline for the rectification process is the previously existing agricultural operation on the farm Roodekopjes. That is, the site was characterised by a farmhouse and related compound area including a small range of farm-operation buildings. An access road ran from the pre-existing gravel provincial road to the farm compound. Limited infrastructure aside the above-mentioned was found on the property.

An **Environmental Scoping Study** (ESS) was initiated in 2009 for the UCG pilot project and associated infrastructure including the 40–140 MW OCGT demonstration plant and gas treatment plants (DEA Ref 12/12/20/1617). The environmental impacts associated with the project required investigation in compliance with the EIA Regulations (2006) published in Government Notice No. R. 385 to No. R. 387 and read with Section 24(5) of the National Environmental Management Act (Act No. 107 of 1998, as amended) (NEMA).

The final **Environmental Scoping Report** for the project was accepted by the Department of Environmental Affairs (DEA) in March 2010.

Prior to the continuation of the EIA phase of the study, advice was sought from DEA, as to whether the applicant could continue with the process and obtain an Environmental Authorisation in terms of the NEMA EIA Regulations (2006).

The DEA indicated that in terms of Regulation 77 of the EIA Regulations (2006) – "*An application or appeal in terms of these Regulations lapses if the applicant or appellant after having submitted the application or appeal fails for a period of six months to comply with a requirement in terms of these Regulations relating to the consideration of the application or appeal*" – that the application has lapsed. The applicant (Eskom) was advised to start the process afresh under the EIA Regulations (2010), and thus to submit a **new EIA application** under the 2010 regulations.

This was started and is ongoing in a parallel application with the DEA (please refer).

Note that no applications with respect to the property and the proposed development have to date been rejected. These include the following approved applications / permits, please refer to **Appendix B** which includes:

- The prospecting right issued converted in terms of the Mineral and Petroleum Resources Development Act 28 of 2002 and the extensions thereof.
- The Exemption from the provisions of the Atmospheric Pollution Prevention Act 45 of 1965 ("APPA") (repealed by the National Environmental Management: Air Quality Act (NEM:AQA), Act No. 39 of 2004) from the relevant Chief Air Pollution Control Officer (CAPCO) dated 16 September 2005.
- A copy of the Exemption granted in terms of section 28A of the Environment Conservation Act No. 73 of 1989 in respect of the undertaking of activities listed in terms of GN 1182 of 7 September 1997 by the then Mpumalanga Department of Agriculture, Conservation and Environment (then MDACE, now MDEDET).
- A pre-directive was issued by the Department of Water Affairs (DWA) on 22 November 2012. The formal IWULA as well as supporting documents submitted to the DWA on 31 January 2013 is under review by the Department and available on request.

During the drafting of the Environmental Impact Assessment Report (EIAR) in consultation with the DEA, it was determined that the various permits did not in fact fully cover the existing Phase 1 Pilot Plant already constructed (i.e. the project at hand), as such it was decided to request rectification in terms of Section 24G of the National Environmental Management Act (NEMA) (as amended).

1.2.3 "Triggered" listed activities

Critically within a Rectification process the consideration of the listed activities that have been triggered by the development undertaken need to be noted. These were presented in the Application form submitted to the DEA but are reiterated for completeness below.

Table 2: Listed activities applied for

ECA EIA Contraventions : Between 08 September 1997 end of day 09 May 2002	
Activities commenced with on or after 08 September 1997 and before end 09 May 2002: EIA Regulations promulgated in terms of the Environment Conservation Act (ECA), Act No 73 of 1989, as amended without the required environmental authorisation.	
Listed Activity	Details of Activity
(None – predates the commencement of the development phase of the UCG project)	

ECA EIA Contraventions : Between 10 May 2002 and before end of day 02 July 2006	
Activities commenced with on or after 10 May 2002 and before end 02 July 2006: EIA Regulations promulgated in terms of the ECA, Act No 73 of 1989, as amended without the required environmental authorisation.	
Listed Activity	Details of Activity
1(c)	The construction or upgrading of: (c) infrastructure for the transportation of any substance which is dangerous or hazardous and is controlled by national legislation. *This is taken to refer to the pipelines installed from the UCG pilot plant site to the Majuba Power Plant. It should however be noted that the exemption granted by the Mpumalanga Department of Agriculture, Conservation and Environment (then MDACE, now MDEDET) with reference to Point 17.2.1, specifically states that the Department authorises the construction of gas pipelines between Majuba coalfields and Majuba Power Station to accept gas as a supplementary fuel in the electricity generation process.* *No additional pipelines were constructed after the granting of the Exemption, as such it may be argued that the pipelines were authorised and therefore the aforesaid listed activity may be removed from this application.* *Note is taken that the abovementioned Exemption specifically refers to activity 1(a) and not activity 1(c). However, the Exemption clearly refers to the gas pipelines. It may thus be argued that the pipelines form part of the "facilities" referred to in activity 1(a) and that the Department's omission of activity 1(c) in the Exemption was a mere oversight.*
2(c)	The change of land use from: (c) agriculture or zoned undetermined use or an equivalent zoning, to any other land use. *Land-use change from agricultural to another land-use (i.e. industrial in this case). It may be argued that the activity was not triggered as the nature of prospecting is exploratory and according there is no actual change in land use until mining commences.* *That is, whilst it would appear that this activity is triggered as a result of drilling of the boreholes, the drilling of these boreholes was undertaken pursuant to the already mentioned prospecting right. The nature of a prospecting right is exploratory in nature and accordingly it is arguable that until such time as a mining right is granted, there is no actual change in the land use and accordingly, this activity is not triggered.*
7	The reclamation of land ~~below the high water mark of the sea and~~ in inland water including wetlands. *Access roads associated with the pipelines cross a number of watercourses.*
9	Scheduled processes listed in the second schedule to the Atmospheric Pollution Prevention Act, 1965 (Act No. 45 of 1965) *This activity was triggered as the existing Majuba Power Plant boilers were altered necessitating a provisional registration certificate in terms of the APPA. Although an Exemption from the APPA requirements were obtained with respect to the co-firing operation, the Exemption granted by the MDACE did not include modifications to the Majuba plant so as to facilitate these co-firing events (i.e. the insertion of 36 (thirty-six) gas*

ECA EIA Contraventions : Between 10 May 2002 and before end of day 02 July 2006	
	lances into the existing bins, but no further infrastructural changes taking place).

Notes:

1. Activity 8 was not included in the listing above as the disposal of waste occurred at a registered disposal site, i.e. at Majuba Power Plant's dedicated waste site.
2. Activities which commenced (construction or operation) prior to this time period (i.e. prior to 10 May 2002) are not reiterated here as the activity is deemed to be triggered prior to the relevant activity coming into operation (i.e. already constructed / commenced).

NEMA EIA Contraventions : Between 03 July 2006 and before end of day 01 August 2010	
Activities commenced with in terms of the EIA Regulations promulgated in terms of the NEMA, Act No 107 of 1998, as amended on or after 03 July 2006 and before end of day 01 August 2010 without the required environmental authorisation	
GNR 386 Activity No.	Details of Activity requiring Basic Assessment
1 (n)	The off-stream storage of water, including dams and reservoirs, with a capacity of 50,000 m^3 or more, unless such storage falls within the ambit of the activity listed in item 6 of GNR 387 of 2006. *The construction of the raw water dam.*
1 (p)	The temporary storage of hazardous waste. *The construction and operation of the condensate dam.* *Note that the activity was deemed to be triggered as the construction and initial operation of the condensate dam was prior to the waste activities being removed from the general EIA regulations. That is, this specific activity was deleted from the NEMA Listed Activities with the commencement of the National Environmental Management: Waste Act (NEM:WA, Act No. 59 of 2008) and the accompanying waste management activities listed in GN 718 of 3 July 2009.* *If the activity had commenced <u>after</u> the waste management activities came into operation, then it is the opinion of the applicant"s legal team that rectification could not be granted for this specific activity as Section 24G of NEMA cannot be applied to the waste management activities by virtue of the wording of Section 24F of the NEMA (which refers to activities listed in terms of Section 24 of the NEMA) and the fact that the waste management activities are not listed in terms of Section 24 of the NEMA.* *The argument above is however not of relevance to the construction and operation of the condensate dam as it stands as this commenced when activity 1(p) was active and within the ambit of NEMA.* *Note that the decommissioning and rehabilitation of the condensate dam, along with the construction of a new alternative site and/or holding option does fall within NEM:WA and as such a separate waste management licence will be applied for in terms of the NEMWA. The parallel EIA process will be updated to include this activity.*
4	The dredging, excavation, infilling, removal or moving of soil, sand or rock exceeding 5 m^3 from a river, ~~tidal lagoon, tidal river, lake, in-stream dam,~~ floodplain or wetland. *This is potentially triggered via ongoing maintenance operations which may have potentially moved this amount of material.* *Further potential movements in excess of this volume of material from within the floodplain may have been triggered by the borrow-pit on the floodplain and the small perched-water table wetland above it.*
7	The above ground storage of a dangerous good, including petrol, diesel, liquid petroleum gas or paraffin, in containers with a combined capacity of more than 30 m^3 but less than 1,000 m^3 at any one (1) location or site. *The aboveground diesel storage tanks are in excess of 30 m^3 (i.e. combined capacity is 46 m^3 (2 x 23 m^3 tanks)).*
13	The abstraction of groundwater at a volume where any general authorisation issued in terms of the National Water Act, 1998 (Act No. 36 of 1998) will be exceeded. *It is noted that although raw water is taken from underground sources in small quantities, indirect abstraction of water is undertaken as part of the underground coal gasification process itself, where water is allowed to*

NEMA EIA Contraventions : Between 03 July 2006 and before end of day 01 August 2010	
	infiltrate and participate in the process itself, or be evaporated to steam. Water is also formed during the process. All water derived is conveyed to the surface as steam with the final product, and is thereafter sent to the condensate dam. Note that once the water treatment plant (WTP) is proven, the intention is to link it into the process with water going through it, before the final product is released to the condensate dam. The condensate is held on site prior to disposal off-site. *Options for alternative usage of the condensate are being investigated and remain a key item in the ongoing investigations forming part of the research process.* *Note that this issue is being considered as part of the investigation process being carried out by the Department of Water Affairs (DWA) in a parallel process – a final decision in this regard has not been reached. This investigation needs to determine what the allowable limits are in terms of the general authorisation (GA) applicable to the project area, and thus the applicability of the activity and how it needs to be linked into the existing Majuba water use licence(s) and/or GAs.* *With respect to the WTP – the current condensate treatment plant is still under research and the system will need to be run over time so as to perform tests to determine the final optimal solution.*
15	The construction of a road that is wider than 4 m or that has a reserve wider than 6 m, ~~excluding roads that fall within the ambit of another listed activity or which are access roads of less than 30 m long~~. *The construction of the new access roads – completion of this process.*
16	The transformation of undeveloped, vacant or derelict land to – (b) ~~residential, mixed, retail, commercial,~~ industrial ~~or institutional~~ use where such development does not constitute infill and where the total area to be transformed is bigger than 1 ha. *The development of the additional infrastructure including the completion of the gas treatment plant (GTP), the WTP, and, the two (2) dams (raw and condensate), plus all ancillary activities, occupy a footprint of larger than 1 ha in total.*
17	Phased activities where any one phase of the activity may be below a threshold specified in this Schedule but where a combination of the phases, including expansions or extensions, will exceed a specified threshold. *The phasic nature of a research project means that the inclusion of this activity is mandatory. This is especially critical with the ramping up and bringing in of infrastructure sequentially over a number of years. This fits with the overall consideration of the pilot plant as being a research project which by default is iterative or phasic in nature.*

Notes:

1. The storage of coal / ore-specific activities are not triggered as the coal remains *in situ* and as such does not require stockpiling with its related risks.
2. Mining-specific activities were dormant at this time and thus not considered in the above listing.
3. Activity 1(m) (construction within a watercourse or 32 m thereof) is not included in the list above as the construction process on the pipeline and associated access roads began prior to this time period. These activities were carried out in terms of the exemption granted under the ECA. The final construction activities related thereto that may have run into this time period, along with routine maintenance, are thus not deemed to be ~~c~~onstruction", but rather continuance of an approved activity.
4. Activity 19 is not included as the GTP and WTP are considered to be treatment facilities and not manufacturing facilities. The word —ma~~n~~ufacturing" as referred to in the activity is not defined in the EIA Regulations and, in terms of the rules of interpretation, the ordinary dictionary meaning may be applied. —M~~m~~anufacture" means to make something on a large scale – which given this is a pilot plant is not considered to be applicable.
5. Activities which commenced (construction or operation) prior to this time period (i.e. prior to 3 July 2006) are not reiterated here as the activity is deemed to be triggered prior to the relevant activity coming into operation (i.e. already constructed / commenced).
6. Waste management specific activities were repealed / excised from this schedule on the 3 July 2009. Activities that are waste-specific that are deemed to be triggered in terms of this schedule are only considered to be relevant if the commencement date was thus between 3 July 2006 to 3 July 2009 (rather than the full period up until 1 August 2010). If commencement was after the 3 July 2009 the activity would be in terms of NEM:WA and would thus not fall within the ambit of the S24G rectification process.

NEMA EIA Contraventions : Between 03 July 2006 and before end of day 01 August 2010	
Activities commenced with in terms of the EIA Regulations promulgated in terms of the NEMA, Act No 107 of 1998, as amended on or after 03 July 2006 and before end of day 01 August 2010 without the required environmental authorisation	
GNR 387 Activity No.	Details of Activity requiring Scoping Report and EIA
1 (e)	The construction of facilities or infrastructure, including associated structures or infrastructure, for – (e) any process or activity which requires a permit or license in terms of legislation governing the generation or release of emissions, pollution, effluent or waste and which is not identified in GNR. 386 of 2006. *Air permit requirements could be triggered – potentially for the flaring on the site itself and for the co-firing at Majuba. It is however noted that the co-firing events of the UCG generated gas in Unit 4 at Majuba Power Station was granted exemption from Sections 6.1 and 6.3 of Majuba's APPA Registration Certificate (No. 1448/1). Further, in terms of the flaring events, it is understood that "*test or experimental installations*" are excluded from "*Category 3: Carbonization and Coal Gasification, subcategory 3.1: Combustion installations*" of NEM:AQA. The UCG Pilot Project is thus deemed to not trigger a listed activity in terms of the NEM: AQA linkage.* *The condensate is a hazardous effluent and requires a water use licence relating to effluent handling and storage.*
1 (i)	The extraction or processing of natural gas including gas from landfill sites. *The gasification process itself could trigger this activity, the uncertainty is due to the definition of the term "*natural gas*". The word "*natural gas*" is not defined in the EIA Regulations, as such the definition for "*natural gas*" from the Gas Act (Act No. 48 of 2001) was considered relevant where "*natural gas*" is included in the definition of the term "*gas*" which means "*all hydrocarbon gases transported by pipeline, including natural gas, artificial gas, hydrogen rich gas, methane rich gas, synthetic gas, coal bed methane gas, liquefied natural gas, compressed natural gas, re-gasified liquefied natural gas, liquefied petroleum gas or any combination thereof*". It is considered that UCG-derived gas can thus be taken to fall within this definition.*
1 (q)	The ~~incineration, burning,~~ evaporation, ~~thermal treatment, roasting or heat sterilisation~~ of ~~waste or~~ effluent~~, including the cremation of human or animal tissue.~~ *The condensate dam may be considered to fall within this definition as the intention is to concentrate the condensate through evaporation prior to removal from the site.* *As per activity 1(p) of GN R386 (above) the condensate dam was constructed prior to the activity being removed from this schedule and thus was relevant at the time of construction.* *The decommissioning of the condensate dam has not occurred at this time and will be linked to a waste management specific permitting requirement – which is to be linked into the parallel EIA process for the next phase of the UCG pilot plant.*
Notes: 1. The storage of coal / ore-related activities are not triggered as the coal remains *in situ* and as such does not require stockpiling with its related risks. 2. Mining specific activities were dormant and thus not considered in the above listing. 3. Activities which commenced (construction or operation) prior to this time period (i.e. prior to 3 July 2006) are not reiterated here as the activity is deemed to be triggered prior to the relevant activity coming into operation (i.e. already constructed / commenced). 4. Waste management specific activities were repealed / excised from this schedule on the 3 July 2009. Activities that are waste-specific that are deemed to be triggered in terms of this schedule are only considered to be relevant if the commencement date was thus between 3 July 2006 to 3 July 2009 (rather than the full period up until 1 August 2010). If commencement was after the 3 July 2009 the activity would be in terms of NEM:WA and would thus not fall within the ambit of the S24G rectification process.	

NEMA EIA Contraventions : On or after 02 August 2010	
Activities commenced with in terms of the EIA Regulations promulgated in terms of the NEMA, Act No 107 of 1998, as amended on or after 02 August 2010 without the required environmental authorisation	
GNR 544 Activity No.	Details of Activity requiring Basic Assessment
18	The infilling or depositing of any material of more than 5 m^3 into, or the dredging, excavation, removal or moving of soil, sand, ~~shells, shell grit,~~ pebbles or rock from (i) a watercourse; – but excluding … (*no exclusions relevant*) *This relates to the maintenance operations on the watercourse crossings, especially the site where the access road bridge servicing the pipeline and the pipeline's footings that were previously installed across the river were severely damaged by a flood event. Note that final rehabilitation has not been completed on this bridge as the fate thereof needs to be confirmed before any additional work is undertaken.*
GNR 545 Activity No	Details of Activity requiring a Scoping Report and EIA
No new activities relating to this schedule of listed activities were triggered (i.e. commenced construction / operation) during this period (i.e. on or after 2 August 2010)	
GNR 546 Activity No.	Details of Activity requiring Basic Assessment
No new activities relating to this schedule of listed activities were triggered (i.e. commenced construction / operation) during this period (i.e. on or after 2 August 2010)	

Notes:

1. Mining-specific listed activities within the regulations remain dormant at this time (i.e. a mining activity is not controlled by the EIA regulations at this time unless it triggers other active activities) and thus are not considered in the above listing.
2. No additional hazardous substances are intended to be placed on the site. The potential new condensate dam is not considered under this listing as it is a —waste storage lagoon" and will be handled in terms of the waste-specific legislation as an addition to the on-going parallel EIA process for the next phase of the UCG pilot plant. This is one of the on-going research items as to how to handle the condensate and gain possible benefits there from if at all viable.
3. Maintenance operations for the bridge and foundation of the pipeline where it crosses the watercourse has undergone some maintenance operations post a flood event. This maintenance however has been to stabilise the existing infrastructure and as such has not lead to an overall increase in the footprint of the activity (i.e. not an upgrading or expansion). That is, the existing road crossing and pipeline footings will not be significantly expanded but rather replaced to the pre-existing footprint as was in place prior to the flood. Note that the final rehabilitation of the bridge and footings has not been carried out at this time and will only be carried out once guidance is received from the DEA on the remainder of the process at hand.
4. No additional hazardous substance storage has been added to the site since listed under the previous sets of regulations and the threshold remains below the 80 m^3 level.
5. No additional roads have been constructed in this period (i.e. since 2010), including no new expansions to existing roads, and thus the related activities are not specified in the list above. As such whether the roads occur within sensitive areas is not of relevance as the roads were constructed prior to 2 August 2010 and thus were deemed to be extant when Schedule 3 came into use.
6. No significant additional footprint increases are believed to have occurred – all activities remain within the previously delineated areas of operation. Thus the need to include activities related to changes to areas of vegetation being affected is deemed to not be of relevance. If this is considered to be an incorrect assumption then activities 12, 13 and possibly 14 of listing notice 3 (GNR 546) should be included in the listing above.
7. No decommissioning activities have occurred, although some items of the process are currently dormant (i.e. WTP), or require decommissioning (i.e. condensate dam). The old GTP was decommissioned and deconstructed
8. No additional gas pipelines have been constructed during this period. It should further be noted that the threshold of 700 tons per day for the bulk transportation of gaseous hazardous substances is not reached and as such the related activity is deemed to not be applicable.
9. Gas generation is deemed on-going and thus activities relating to commencement of activities requiring an air emissions

NEMA EIA Contraventions : On or after 02 August 2010
permit are not included in this set of regulations. 10. Activities which commenced (construction or operation) prior to this time period (i.e. prior to 2 August 2010) are not reiterated here as the activity is deemed to be triggered prior to the relevant activity coming into operation (i.e. already constructed / commenced).

1.3 Approach to the Environmental Impact Study

The environmental impacts associated with the proposed project to date have required investigation in compliance with the EIA Regulations (2010) published in Government Notice No. R. 543 to No. R. 546 and read with Section 24 (5) of the National Environmental Management Act (Act No. 107 of 1998) (NEMA) (as amended), as well as the National Environmental Management: Waste Act (Act No. 59 of 2008) (NEM:WA). An integrated environmental authorisation process has thus been followed with the Minister (Environmental Affairs) as both the:

(a) competent authority for the environmental authorisation applied for in terms of the EIA Regulations, 2010 promulgated under NEMA; and

(b) the licensing authority for the waste management licence in terms of NEM:WA.

The ongoing required environmental studies include the undertaking of an Environmental Impact Assessment (EIA) process. This process has being undertaken in two (2) phases (see **Figure 4**) that will ultimately allow the competent authority (Department of Environmental Affairs) to make an informed decision:

- Phase 1 – Environmental Scoping Study (ESS) including Plan of Study for EIA (***complete***); and
- Phase 2 – Environmental Impact Assessment (EIA) and Environmental Management Programme (EMPr) (***on hold***).

The rectification process as required through the process at hand is effectively a parallel process that takes information from that generated to date and is required to be finalised prior to the EIAR being submitted to the DEA for potential environmental authorisation in terms of NEMA and NEM:WA.

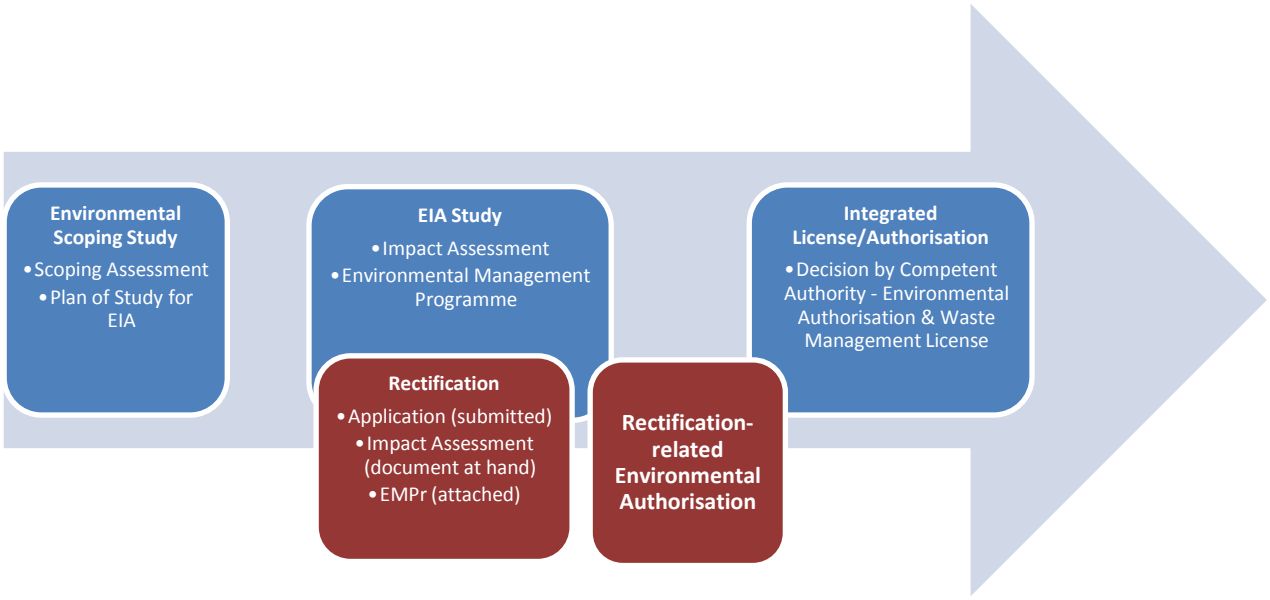


Figure 4: Environmental studies flowchart

In the formal response from the DEA to the formal Section 24G (S24G) Application submitted, the following requirements (**Table 3**) were highlighted as being necessary to submit. The dominant point where the information is found is detailed below, it should however be noted that in many instances other portions of the document will also touch on the specific issue of note.

Table 3: Requirements as per DEA feedback letter in response to the Rectification Application

EIAR Report Requirements	
DEA requirement	Section of relevance
An assessment of the nature, extent, duration and significance of the consequence for or impacts on the environment of each of the activities unlawfully commenced with	Section 8
An assessment of the nature, extent, duration and significance of the consequence for or impacts on the environment of the cumulative effects that the activities unlawfully commenced with have had and will have on the environment	Section 8
A description of mitigation measures undertaken or to be undertaken in respect of the consequences for or the impacts on the environment of the activities unlawfully commended with	Section 8 & EMPr
A description of the Public Participation Process followed during the course of compiling the report, including all comments received from I&APS and an indication giving effect to the manner in which these were addressed	Section 6
A4 (210 mm X 290mm) colour photographs of the site and each illegal activity and Transgression point *(to be included in the final document as high resolution A4 photographs – smaller photographs are presented in the draft document)*	Appendix D
The details of- (a) the EAP who complied with the report; (b) the expertise of the EAP to carry out an environmental impact assessment	Section 1.6
A sworn affidavit by the EAP that the information provided to the Department was at no stage influenced by the applicant. This includes any information provided to the Department during the submission phase of the application	Appendix C
A detailed description of the scope of the development, including the extent thereof, must be indicated on a map and according to scale	Figure 1, Appendix A
A description of the environment that has been and may further be affected by the activity and the manner in which the physical, biological, social, economic and cultural aspects of the environment has been or may further be affected by the proposed activity	Section 5
A description of the need and desirability of the activity	Section 1.1
A detailed description and comparative assessment of the potential alternatives to the proposed activity, including advantaged and disadvantages that the activity or alternatives may have on the environment. The effects of this development on the affected community must be described	Section 4
An indication of the methodology used in determining the significance of potential environmental impacts	Section 8.1

EIAR Report Requirements	
DEA requirement	Section of relevance
A summary of the findings and recommendations of any specialist report or report on a specialised process; (a) details of— (i) the person who prepared the report; and (ii) the expertise of that person to carry out the specialist study or specialised process; (b) a declaration that the person is independent in a form as may be specified by the competent authority; (c) an indication of the scope of, and the purpose for which, the report was prepared; (d) a description of the methodology adopted in preparing the report or carrying out the specialised process; (e) a description of any assumptions made and any uncertainties or gaps in knowledge; (f) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment; (g) recommendations in respect of any mitigation measures that should be considered by the applicant and the competent authority; (h) a description of any consultation process that was undertaken during the course of carrying out the study; (i) a summary and copies of any comments that were received during any consultation process	Section 7
A description of all environmental issues that were identified during the environmental impact assessment process, an assessment of the significance of each issue and an indication of the extent to which the issue could be addressed by the adoption of mitigation measures	Section 8
An assessment of each identified potentially significant impact, including— (i) cumulative impacts; (ii) the nature of the impact; (iii) the extent and duration of the impact; (iv) the probability of the impact occurring; (v) the degree to which the impact can be reversed; (vi) the degree to which the impact may cause irreplaceable loss of resources; and (vii) the degree to which the impact can be mitigated	Section 8
A description of any assumptions, uncertainties and gaps in knowledge.	Section 9.5
A reasoned opinion as to whether the activity should or should not be authorised, and if the opinion is that it should be authorised, any conditions that should be made in respect of that authorisation	Sections 9.3 & 9.4
An environmental impact statement which contains— (i) a summary of the key findings of the environmental impact assessment; and (ii) a comparative assessment of the positive and negative implications of the proposed activity and identified alternatives	Section 9
Motivation of why your application in terms of Section 24G should be considered favourably	Section 9.3

EMPr Report Requirements	
DEA requirement	Section of relevance
An assessment of the nature, extent, duration and significance of the consequence for or impacts on the environment of each of the activities unlawfully commenced with	EIAR & EMPr: Sections 7 – 11
An environmental management programme including: (a) details of – (i) the person who prepared the environmental management programme; and (ii) the expertise of that person to prepare an environmental management programme.	EMPr: Section 4.2
(b) information on any proposed management or mitigation measures that will be taken to address the environmental impacts that have been identified in the EIR, including environmental impacts or objectives in respect of— (i) planning and design; (ii) pre-construction and construction activities; (iii) operation or undertaking of the activity; (iv) rehabilitation of the environment; and (v) closure.	EMPr: Sections 8 – 11
(c) an identification of the persons who will be responsible for the implementation of the measures as above.	EMPr: Section 6
(d) a detailed description of the aspects of the activity that are covered by the draft environmental management programme.	EMPr: Section 3
(e) proposed mechanisms for monitoring compliance with and performance assessment against the environmental management programme and reporting thereon.	EMPr: Sections 6.3. – 6.5.
(f) as far as is reasonably practicable, measures to rehabilitate the environment affected by the undertaking of any listed activity or specified activity to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development, including, where appropriate, concurrent or progressive rehabilitation measures.	EMPr: Sections 8 – 11
(g) a description of the manner in which it intends to— (i) modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation; (ii) remedy the cause of pollution or degradation and migration of pollutants; (iii) comply with any prescribed environmental management standards or practices.	EMPr: Sections 8 – 11
(h) time periods within which the measures contemplated in the environment management programme must be implemented.	EMPr: Sections 8 – 11
(i) the process for managing any environmental damage, pollution, pumping and treatment of extraneous water or ecological degradation as a result of undertaking a listed activity.	EMPr: Sections 8 – 11
(j) an environmental awareness plan describing the manner in which— (i) the applicant intends to inform his or her employees of any environmental risk which may result from their work; and (ii) risks must be dealt with in order to avoid pollution or the degradation of the environment.	EMPr: Section 7
Closure plans including closure objectives.	EMPr: Section 11

PPP Requirements	
DEA requirement	Section of relevance
A fixed notice board must have been erected at a place conspicuous to the public at the boundary or on the fence of the site where the activity occurred.	Section 5 & Appendix E
Proof that written notices was given to- (a) the owner or person in control of that land if the applicant is not the owner or person in control of the land; (b) owners and occupiers of land adjacent to the site where the activity is or is to be undertaken or to any alternative site where the activity is to be undertaken; (c) the municipal councillor of the ward in which the site or alternative site is situated and any organisation of ratepayers that represent the community in the area; (d) the municipality which has jurisdiction in the area; (e) any organ of state having jurisdiction in respect of any aspect of the activity.	Section 5 & Appendix E
An advertisement must have been placed in at least one local and one provincial newspaper.	Section 5 & Appendix E
A description of the manner in which a person was accommodated in instances where a person wished/wishes to be involved in the process but is unable to participate in the process due to- (a) illiteracy; (b) disability; or (c) any other disadvantage	Section 5 & Appendix E
The notice, notice board or advertisement referred to above must have— (a) given details of the application which is subjected to public participation; and (b) state— (i) that the application has been submitted to the competent authority; (ii) that application is for the rectification of an illegal activity; (iii) a list of illegal activities transgressed; (iv) the nature and location of the activity to which the application relates; (v) where further information on the application or the activity can be obtained; and (vi)the manner in which and the person to whom representations in respect of the application may be made.	Section 5 & Appendix E
The notice board referred to above must have been at least— (a) a of a size at least 60cm by 42cm; and (b) display the required information set out above in lettering and in a format that is legible and clear.	Section 5 & Appendix E
A register must be opened and maintained, which contains the names, contact details and addresses of— (a) all persons who, as a consequence of the public participation process conducted in respect of the application, have submitted written comments or attended meetings with the applicant or EAP; (b) all persons who, after completion of the public participation process have requested the applicant or the EAP managing the application, in writing, for their names to be placed on the register; and (c) all organs of state which have jurisdiction in respect of the activity to which the application relates.	Section 5 & Appendix E
The EAP must give access to the register to any person who submits a request for access to the register in writing.	Accepted, been allowed at all times
The EAP must ensure that the comments of interested and affected parties are recorded in the reports and that such written comments, including records of meetings, are attached to the report referred to above.	Section 5 & Appendix E

1.3.1 Specialist Studies

RHDHV was assisted by various specialists during the parallel EIAR process in order to comprehensively identify both potentially positive and negative environmental impacts (social and biophysical) associated with project and where possible mitigate these potential impacts. The specialist team have been involved in the project since 2010 and have assessed the study area including the adjacent farms (Rietfontein 66 HS (including Klein Rietfontein 117HS); Japtrap 115HS; Palmietspruit 68HS; Tweedepoort 54HS; Koppieskraal 56HS; Bergvliet 65HS; Weiland 59HS and Strydkraal 53HS). Golder Associates Africa (Pty) Ltd have been involved in groundwater monitoring on the farm Roodekopjes 67HS since 2006.

Since the existing Pilot Plant Phase 1 infrastructure was developed around these time periods, the specialist information drawn into this report comes from that specialist information.

The specialist team and their fields of expertise are outlined in **Table 4**.

Table 4: Specialist studies

Specialist Field	Specialist and Organisation
External Specialists	
Hydrogeology[1]	*Gerhard van der Linde – Golder Associates Africa (Pty) Ltd*
Hydrology	*Lee Boyd – Golder Associates Africa (Pty) Ltd*
Soils and Agricultural Potential	*Dr Johan van der Waals – Terra Soil Science*
Biodiversity	*Riaan Robbeson – Bathusi Environmental Consulting* *Dewald Kamffer – Faunal Specialists Incorporated*
Heritage	*Dr Johnny van Schalkwyk – Private*
Social	*Nonka Byker – RS Risk Solutions*
RHDHV Resources providing input into Specialised Processes	
Wetlands	*Paul da Cruz – Royal HaskoningDHV*
Freshwater Ecology (Aquatic)	*Earl Herdien – Royal HaskoningDHV* *(was RHDHV staff member when the document was generated)*
Waste	*Siva Chetty – Royal HaskoningDHV*
Visual	*Paul da Cruz – Royal HaskoningDHV*
Air Quality	*Stuart Thompson & Lodewyk Jansen – Royal HaskoningDHV*

It should be noted that a micro-economic study was also commissioned during the previous Scoping exercise under the 2006 EIA Regulations, however, it will not be included as part of this study as the project scope has been significantly reduced. Furthermore UCG technology is still under research and will only be implemented on Eskom-owned land (i.e. Roodekopjes 67HS).

1.4 Concurrent Licensing Processes

1.4.1 Mining Right

Eskom has lodged a mining rights application in terms of Section 22 of the MPRDA with the DMR that was subsequently accepted on 11 September 2012 (Ref MP 30/5/1/1/2/10031 MR). A mining-specific Environmental Management Programme (EMPR) has been compiled by Eskom according to Section 39 of the MPRDA.

[1] *Peer reviewed by Phillip Hobbs (CSIR).*

1.4.2 Integrated Water Use License

In terms of Chapter 4 of the National Water Act (No. 36 of 1998) [NWA], activities and processes associated with the UCG operations are required to be licensed by the Department of Water Affairs (DWA).

An integrated Water Use License Application (IWULA) has been lodged with the DWA on 31 January 2013 following a pre-directive issued by the Department on 22 November 2012 (**Appendix B**).

An on-going process is being undertaken with the DWA regarding the existing water uses on the site – this process is running in parallel with the other authorisation processes (i.e. the parallel EIAR and the rectification at hand), with the requirements for the DWA in terms of the NWA currently being provided on behalf of Eskom.

Furthermore, an Integrated Water and Waste Management Plan (IWWMP) has been compiled in support of the IWULA and will be submitted with the parallel EIAR. This document is in draft format at this time, but can be provided on request.

The following water uses (**Table 5**), as defined in section 21 of the NWA, have been applied for in terms of the NWA for the UCG operations.

Table 5: Water uses associated with the UCG operations

S21	Description according to NWA	Use	Applied for	Already Constructed	Planned Expansion	General Authorisation
a	Taking water from water resource	Ground water removal / abstraction as result of UCG process	X	X		X
		Domestic water use	Amendment of Eskom bulk Licence No. 27/2/1/C211/1/1 (correction of property details)			
b	Storing water	Raw water holding dam – domestic use	X	X		X
		Process water holding dam	X	X		
c	Impeding or diverting flow of water in watercourse	11 crossings (road and pipeline)	X	X		
d	Engaging in stream flow reduction activity	**Not applicable**				
e	Engaging in controlled activity	Irrigation of pastures with treated process waste-water	X		X	
		Re-injection of treated process wastewater into aquifer				
f	Discharging waste or water containing waste into water resource through pipe, canal, sewer, sea outfall or other conduit	**Not applicable**				
g	Disposing of waste in manner which may detrimentally impact on water resource	Registration of waste-water treatment works at Mine offices	X	X		X
		Waste-Water Treatment works – condensate water	X		X	
h	Disposing in any manner of water which contains waste from or which has been	Waste-Water generated from power generation process	X	X		

S21	Description according to NWA	Use	Applied for	Already Constructed	Planned Expansion	General Authorisation
	heated in, any industrial or power generation process					
i	Altering bed, banks, course or characteristics of water course	11 crossings (road and pipeline)	X	X		
j	Removing, discharging or disposing of water found underground if it is necessary for efficient continuation of activity or for safety of people	Groundwater removal during UCG process – combined with process water for disposal	X	X		
K	Using water for recreational purposes	**Not applicable**				

1.4.3 Air Emissions License

On 06 September 2012, Eskom requested exemption from the Gert Sibande District Municipality from sections 6.1 and 6.3 of Majuba Power Station's APPA Registration Certificate (number 1448/1) to allow the co-firing of UCG gas in Unit 4 at Majuba Power Station.

The exemption request stipulated the following conditions that would be complied with for the co-firing:

- Maximum permitted consumption rate of UCG gas: 15,000 Nm^3/hr.
- Sulphur content of fuel: 0.2% H_2S (all of which will be oxidized during combustion to form SO_2).
- Ash content of the fuel is 40 mg/Nm^3.

A further request was that the exemption be valid from 28 September 2012, until a new Atmospheric Emission Licence allowing the use of UCG gas as a raw material and energy source at Majuba Power Station has been issued. On 07 September 2012, the Gert Sibande District Municipality acknowledged Eskom's request and indicated that they have no objection to the co-firing (**Appendix B**).

1.5 Details of the Environmental Assessment Practitioner

Royal HaskoningDHV (RHDHV) (formerly SSI Engineers and Environmental Consultants (Pty) Ltd), was been appointed as the independent Environmental Assessment Practitioner (EAP) by Eskom, to undertake the appropriate environmental studies for this proposed project. The professional team of RHDHV have considerable experience in the environmental management and EIA fields. RHDHV has been involved in and/or managed several of the largest Environmental Impact Assessments undertaken in South Africa to date, some of which included the Medupi Power Station, Gautrain, Transnet New Multi Products Pipeline, Platinum Highway, etc.

A specialist area of focus is on the assessment of multi-faceted projects, including the establishment of linear developments (i.e. national and provincial roads, and power lines), bulk infrastructure and supply (e.g. wastewater treatment works, pipelines, landfills), electricity generation and transmission, the mining industry, urban, rural and township developments, environmental aspects of Local Integrated Development Plans (LIDPs), as well as general environmental planning, development and management.

The particulars of the EAP are presented in **Table 6** overleaf.

Table 6: Details of EAP

Details	
Consultant	Royal HaskoningDHV
Contact Persons	Malcolm Roods, Bronwen Griffiths and Prashika Reddy
Postal Address	PO Box 867, Gallo Manor, 2052
Telephone	(MR) 011 798 6442 (BG) 021 936 7714 (PR) 012 367 5973
Facsimile	(MR) 011 798 6010 (BG) 021 936 7611 (PR) 012 367 5878
E-mail	(MR) malcolm.roods@rhdhv.com (BG) bronwen.griffiths@rhdhv.com (PR) prashika.reddy@rhdhv.com
Expertise	• **Malcolm Roods** is a Principal with RHDHV specializing in Environmental Impact Assessments (EIA) for electricity supply (generation, transmission and distribution), road infrastructure, residential developments as well as water management projects. This builds on a broad government background, which has made him particularly flexible. His past experiences include 6 years public service which included policy development, environmental law reform and EIA reviews. His experience includes 6 years of environmental consulting in the field of Impact Assessment and Authorisation Applications, with a focus on legislative requirements and sector area management. He is also a certified Environmental Assessment Practitioner with the Interim Certification Board (ICB) for EAPs of South Africa. • **Bronwen Griffiths** is a Senior Environmental Scientist (*PrSciNat 400169/11: Environmental Science*) with an MSc in Conservation Biology. She has the necessary experience in various environmental fields including: environmental impact assessments, environmental management plans/programmes, public participation and environmental monitoring /auditing. She has extensive experience in compiling environmental reports (Screening, Scoping, and EIA Reports) and also brings an ecological knowledge to such projects Ms Griffiths has dealt with a range of environmental projects, including mixed land-use urban development projects, industrial and petrochemical projects. She has functioned as an EAP for these projects, as well as project manager and administrator for the related project teams. Ms Griffiths has worked in the private sector as an EAP as well as working as an environmental official (i.e. Gauteng Provincial Government (GDARD), City of Johannesburg (CoJ)). Ms Griffiths has been author / co-author on a number of environmental guideline documents, (i.e. DEA, CoJ and GDARD). • **Prashika Reddy** is a Senior Environmental Scientist (*PrSciNat 400133/10: Environmental Science*) with a BSc Honours in Geography. She has the necessary experience in various environmental fields including: environmental impact assessments, environmental management plans/programmes, public participation and environmental monitoring and auditing. She has extensive experience in compiling environmental reports (Screening, Scoping, EIA and *Status Quo* Reports). She is/has been part of numerous multi-faceted large–scale projects, including the establishment of linear developments (roads, and power lines); industrial plants; electricity generation plants and mining-related projects. ***NOTE: Ms Reddy is the main EAP on the parallel EIAR process.***

2 PROJECT DESCRIPTION

2.1 UCG Process Principles

The Underground Coal Gasification (UCG) theory was developed in the former U.S.S.R. and is based on the principle of in-situ gasifying of a coal seam to produce a synthesis gas, without the removal of the coal. The coal to gas conversion process is a controlled gasification process which is kept deep underground therefore minimising the impact of the operations. The UCG Pilot plant Phase 1 will provide for an initial generating capacity of approximately 6 MWe, which is sufficient to co-fire a single burner at the Majuba Power Station (refer to **Table 7**).

Pending the success of Pilot Plant Phase 1 gas production the current intention is for Eskom to scale the plant up, the current level being considered is up to 70,000 Nm^3/hr to eventually produce 28 MWe (Pilot Plant Phase 2).

Table 7: Gas production and generating capacity during the UCG project phases

Project Phase	Coal Consumption Total tons	Gas Flow Nm^3/hour	MWe
1A & 1B	5.4 tons/hr	15,000	6
1C	25 tons/hr	70,000	28

Due to the nature of the technology, the Underground Coal Gasification pilot plant will comprise a vast number of activities. A basic flow diagram for the entire process is presented in **Figure 5**.

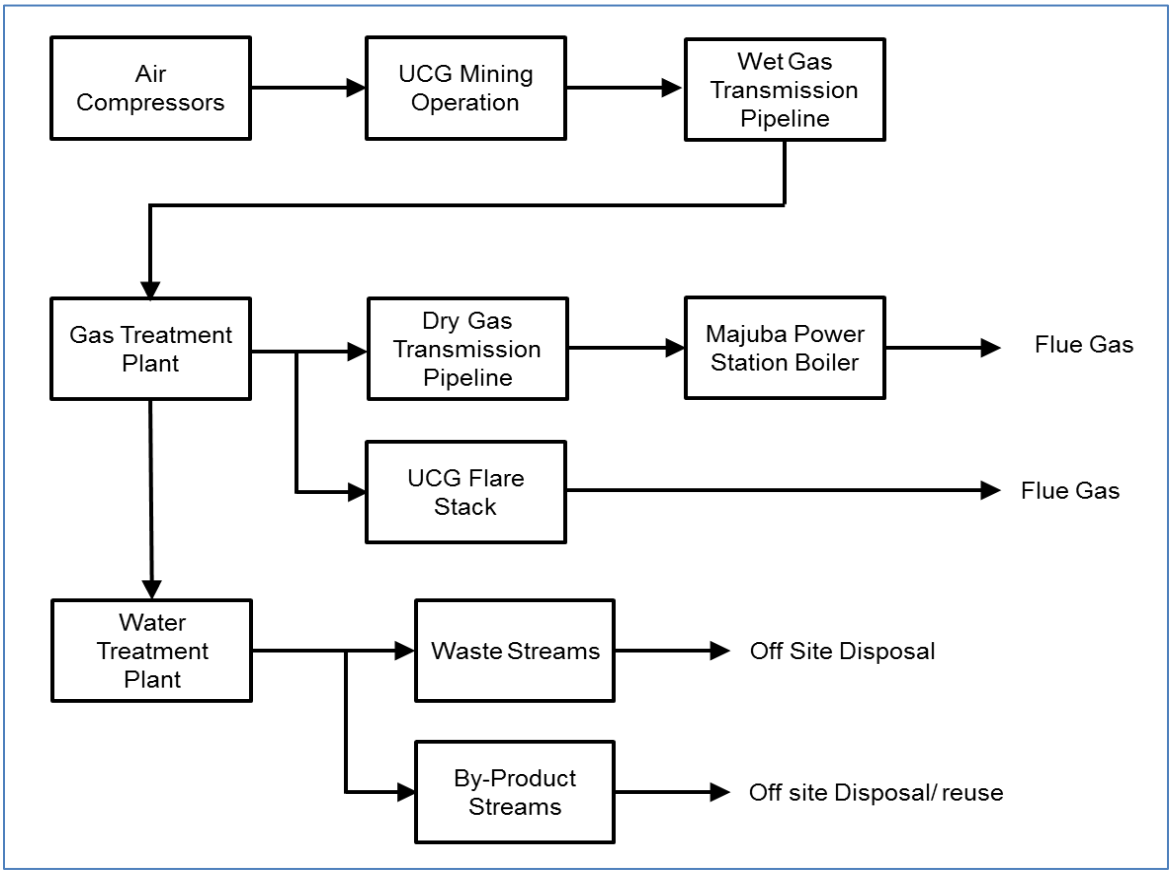


Figure 5: Block flow diagram for the proposed 70,000 Nm^3/hr pilot plant (parallel EIA process)

2.1.1 Air Compressors and Mining Operation

The UCG technology is based on the injection of compressed air (10 bar gauge) provided by large stand-alone air compressors into the coal seam (approximately 280 – 300 m deep).

The main chemical reactions occurring in the underground gasifier are as follows:

Table 8: Main chemical reactions in UCG

Combustion Reactions:		
$C_{(s)} + ½\ O_2 \rightarrow CO_{(g)}$	-111 MJ/kmol	1
$CO_{(s)} + ½\ O_{2(g)} \rightarrow CO_{2(g)}$	-283 MJ/kmol	2
$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$	-394 MJ/kmol	3
$H_2 + ½\ O_{2(g)} \rightarrow H_{2(l)}$	-286 MJ/kmol	4
The Boudouard Reaction		
$CO_{2(g)} + C_{(s)} \rightarrow 2\ CO_{(g)}$	+ 172 MJ/kmol	5
The Water Gas Reaction		
$C_{(s)} + H_2O_{(g)} \rightarrow CO_{(g)} + H_{2(g)}$	+ 131 MJ/kmol	6
The Methanation Reaction		
$C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)}$	-41 MJ/kmol	7

In addition to the above there are a number of homogeneous reactions which occur; these reactions determine the overall syngas composition produced from the gasifier.

Table 9: Main chemical reactions in UCG

Homogeneous Reactions:		
$CO_{(g)} + H_2O_{(g)} \leftrightarrow H_{2(g)} + CO_{2(g)}$	-41 MJ/kmol	1
$CH_{4(g)} + H_2O_{(g)} \leftrightarrow 3H_{2(g)} + CO_{(g)}$	+206 MJ/kmol	2
$CH_{4(g)} + 2O_{2(g)} \leftrightarrow CO_{2(g)} + 2H_2O_{(g)}$	-803 MJ/kmol	3
$Ch_{4(g)} + ½\ O2_{(g)} \leftrightarrow CO_{(g)} + 2H_{2(g)}$	-36 MJ/kmol	4

The above reactions result in the consumption and conversion of the in-seam coal into a syngas which has an estimated composition as displayed in **Table 10**.

Due to the utilisation of coal, the boundaries of the underground reactor continue to grow until such point at which the system is no longer capable of generating a gas of suitable quality. At this stage the specific system is decommissioned and the mine field then proceeds to the next section of available coal.

The gasification reaction displayed above represent the main reactions which occur, there are also a number of other minor reactions which result in the formation of various organic and inorganic trace components in the gas. Of the trace components of interest the main compounds are hydrogen sulphide (H_2S), ammonia (NH_3), phenolic compounds, tars and waxes.

The gasification process also produces a condensate (liquid) stream which is primarily composed of water. The condensate does however contain a small fraction of organic and inorganic impurities which are displayed in the condensate specification table (**Table 11**).

Table 10: UCG pilot plant gas specification

Component	Formula	Minimum Vol%	Optimum Vol%	Maximum Vol%
Methane	CH_4	2.800	3.500	4.500
Ethane	C_2H_6	0.100	0.100	0.100
Propane	C_3H_8	0.050	0.050	0.050
Butane	C_4H_{10}	0.000	0.000	0.000
Pentane	C_5H_{12}	0.000	0.000	0.000
Carbon Monoxide	CO	7.000	9.500	11.000
Hydrogen	H	14.000	15.500	18.000
Hydrogen Sulphide	H_2S	0.200	0.200	0.200
Oxygen	O_2	0.200	0.200	0.200
Water	H_2	5.000	5.000	5.000
Ammonia	NH_3	0.100	0.100	0.100
Nitrogen	N_2	51.950	48.750	44.250
Argon	Ar	0.100	0.100	0.100
Carbon Dioxide	CO_2	18.500	17.000	16.500
Total		**100.000**	**100.000**	**100.00**
LHV [MJ/Nm^3]		**3.554**	**4.283**	**5.100**

Table 11: UCG pilot condensate specification

Description	Minimum	Maximum	Unit
Total Solids per Nm^3	5	40	mg/Nm^3
Total Liquids per Nm^3 gas	25	75	g/Nm^3
ORGANICS			
Benzene	10	22.5	mg/Nm^3
Toluene	1	4.25	mg/Nm^3
m, p - & o-Xylene	0.5	1.25	mg/Nm^3
Naphthalene	10	36.25	mg/Nm^3
Phenol	2,000	4,000	mg/Nm^3
2-Methylphenol	100	275	mg/Nm^3
4-Methylphenol	200	775	mg/Nm^3
Other Organics	10	50	mg/Nm^3
Ammonia	300	1,000	mg/Nm^3
CATIONS and ANIONS			
Ag		<0.01	mg/Nm^3
Al		0.0168	mg/Nm^3
As		0.468	mg/Nm^3
B		0.852	mg/Nm^3
Ba		0.0176	mg/Nm^3
Be		<0.01	mg/Nm^3
Bi		<0.01	mg/Nm^3
Ca		0.306	mg/Nm^3
Cd		<0.01	mg/Nm^3
Co		<0.01	mg/Nm^3
Cr		0.0554	mg/Nm^3
Cu		0.1132	mg/Nm^3
Fe		<0.01	mg/Nm^3
Hg		0.015	mg/Nm^3
K		0.302	mg/Nm^3
Li		<0.01	mg/Nm^3
Mg		<0.01	mg/Nm^3
Mn		<0.01	mg/Nm^3
Mo		<0.01	mg/Nm^3
Na		1.754	mg/Nm^3

Description	Minimum	Maximum	Unit
Ni		0.0368	mg/Nm^3
P		0.0948	mg/Nm^3
Pb		0.0374	mg/Nm^3
S		15	mg/Nm^3
Sb		0.0696	mg/Nm^3
Se		0.316	mg/Nm^3
Si		0.208	mg/Nm^3
Sr		<0.01	mg/Nm^3
Ti		<0. 01	mg/Nm^3
Tl		0.1788	mg/Nm^3
V		<0.01	mg/Nm^3
Zn		0.1936	mg/Nm^3
F		0.924	mg/Nm^3
Cl		130	mg/Nm^3
NO_2		<0.01	mg/Nm^3
NO_3		0.05	mg/Nm^3
PO_4		0.05	mg/Nm^3
SO_4		0.3	mg/Nm^3

The solid portion of the condensate specification includes the tars, waxes and unconverted coal and ash particulates.

The UCG process remains primarily a mining operation and the key components of the mining operation include the drilling, exploration and monitoring wells – also referred to as the gasfield (**Photograph 1**). The gasfield contains two (2) major components namely the gasifier units and ancillary infrastructure such as access roads, pipelines, manifolds etc.

The continuous linkage of wells in the gasifier enables the process to access virgin coal and the monitoring and modelling of the geohydrological, rock mechanics and geological characteristics of the targeted coal seam.

Photograph 1: Representation of a gasfield as seen on the surface[2]

A gasifier unit has an approximate footprint of 50 ha with a maximum height of 15 m and each will be operated independently from one another in order to control the gasification processes.

A typical gasifier unit is made up of the following components:

[2] *Courtesy of Ergo Exergy Technologies Inc, Canada.*

- Above-ground air pipeline
- A network of above ground primary gas pipelines
- A secondary gas pipeline located at the border of the gasification unit
- Injection and production wells
- Water monitoring wells
- Air pressure unit
- Pressure measurement units
- One lane gravel access road
- Wastewater pipeline

The intention is to locate the gasifier units across portions of the farm Roodekopjes 67HS (Portions 1, 2, 3 and remaining extent). Preliminary designs for gasifier units 1 – 3 were developed, although at present only one gasifier (constructed under the auspices of the prospecting right – the subject of this rectification application) is operational. Gasifier unit 1 (Pilot Plant Phase 1) which will be decommissioned over time (part of parallel EIA process) as the underlying coal reserves have been gasified and gasifier unit 2 (Pilot Plant Phase 2 – parallel EIA) will be commissioned.

In terms of the rectification process it should be noted that Gasifier 1 (similarly for all future gasifiers) will be decommissioned and rehabilitated once the gasifier is depleted or the coal resource is completely gasified.

Each gasifier unit will have a production lifetime of approximately 7 – 8 years. The operational lifecycle of a gasifier is dependent on the underlying coal seam thickness and composition. The complete lifecycle for a typical gasifier unit is presented in **Table 12**.

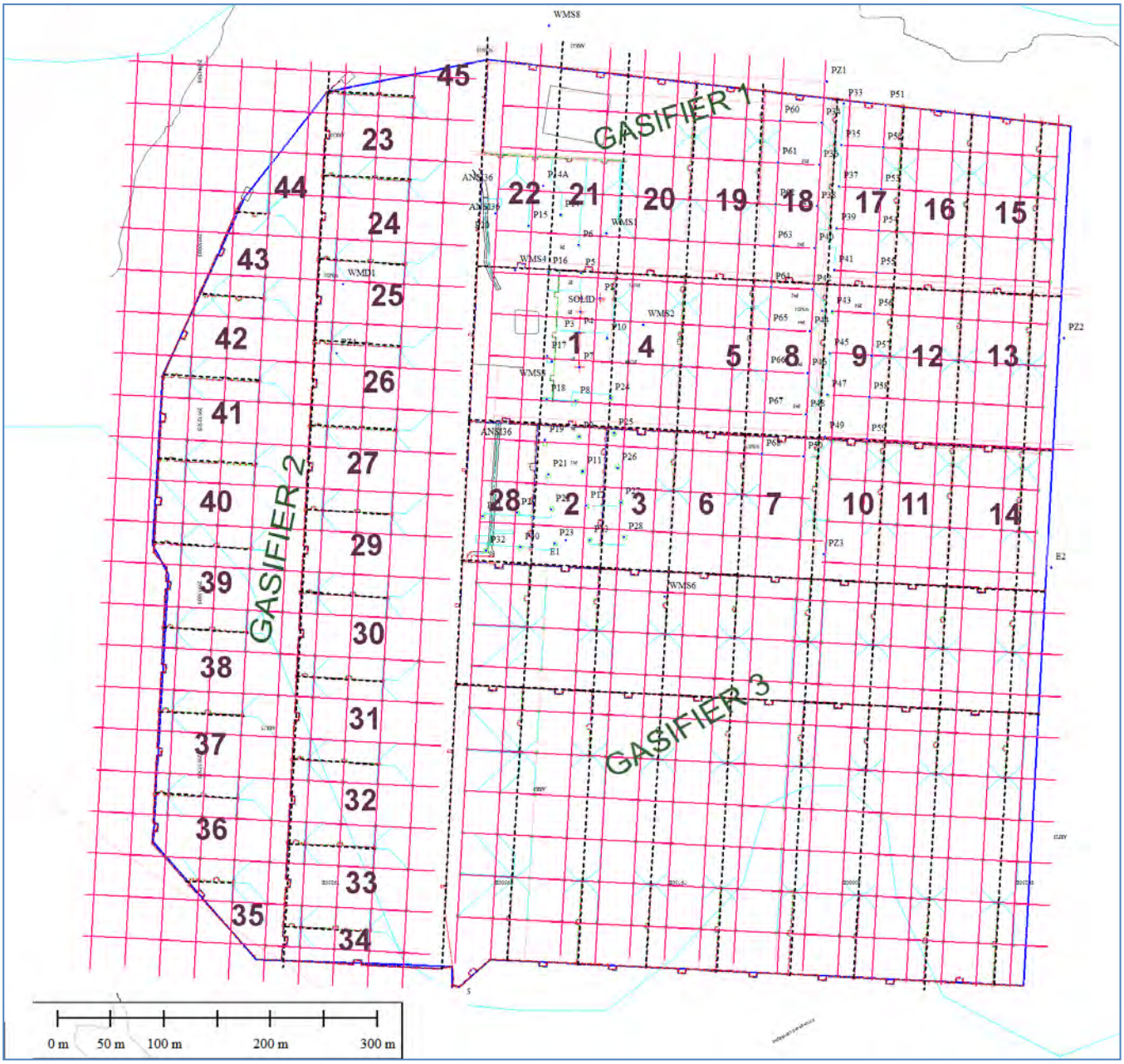


Figure 6: Preliminary layout for gasifiers 1 – 3 (existing Pilot Plant Phase 1 = Gasifier 1)

Table 12: Lifecycle of a gasifier unit

Development Stage	Tasks
Pre-Construction Phase	• Identification of a feasible location for the gasifier unit • Detail designing of the gasifier unit and its operational requirements
Construction Phase	• Marking of gasifier unit footprint and location of wells • Construction of a gravel access road to the gasifier unit from the main infrastructure corridor • Drilling of well structures to the underlying coal seam by using a specialised drilling machine • Securing all wells by inserting a steel lining from the surface of the well to the coal seam and sealing it with concrete • Secure all surface pipelines and test for leakages • Secure all additional infrastructure including the air compressor and water monitoring boreholes
Operational Phase	• Commission the gasifier by commencing the sub-surface gasification reaction through high pressure air injection • Operate gasifier through a series of pipelines and pressure units • Syngas to be transported via primary, secondary, and tertiary gas pipelines to the Gas Treatment Plant • On-going groundwater monitoring
Decommissioning Phase	• Depleted underlying coal reserves will give effect to the decommissioning of a gasifier unit and the commissioning of another gasifier unit • Decommission the gasifier and gasification process by closing all injection wells • Seal wells with concrete mixture • Remove all surface infrastructure • Rehabilitate and re-vegetate all disturbed areas • On-going groundwater monitoring

2.1.2 Gas Treatment and Surface Plant Infrastructure

Once produced, the syngas is brought to surface through the production wells, the gas is diverted to a common manifold which feeds the wet gas transmission pipeline. This 600 mm pipeline is also accompanied by a 50 mm condensate line which returns condensate collected along the pipeline. The wet gas pipeline feeds the gas treatment plant. A simplified gas treatment plant (GTP) is commissioned and is currently operating at the UCG facility.

The extent of the GTP is approximately 30 m x 60 m and consists of the following components:

- Heat exchanger – cooling towers
- Liquid separation vessels
- Emergency gas flare stack – approximate height of 9 m
- Auxiliary pumps, motors and other small equipment

As displayed in **Figure 5**, the gas treatment plant removes the liquid portion present in the gas and supplies a further dry gas transmission pipeline with dry gas. This dry gas is either piped to the Majuba Power Station for combustion along with coal or it is flared on site if the boiler is unavailable.

The resulting flue gas emissions from the flaring and or co-firing of gas are presented in **Table 13** overleaf.

Table 13: Flue gas emission estimates for UCG project

Component	Estimated Emissions [mg/Nm^3] at 10% O_2 and 101.325 kPa – Dry Basis
Carbon Monoxide (CO)	1,024
Hydrogen Sulphide (H_2S)	17
Ammonia (NH_3)	10
Sulphur Dioxide (SO_2)	1,596
Oxides of Nitrogen	942
Volatile Organic Compounds	226
Particulate Matter	<50

** These estimates are based on chemical combustion modelling and will be verified during actual operations*

2.1.3 Waste Streams from the UCG Process

The waste and by-product streams produced by the UCG operations include:

Table 14: Waste streams and by-products produced by the UCG operations

Waste Stream	Quantity	Proposed Handling
UCG condensate	Currently the wastewater generated is disposed off-site as and when required. 1,281 m^3 thus far (Based on 30.5 m^3 / truck, 42 trucks) *Ad-Hoc*	Treatment off site – Enbitec (Order No: 3070034490)
Brine	3 g per litre @ 46,000 m^3	The brine will be disposed off site *via* a contractor to a registered disposal site
Treated wastewater effluent	18,500 m^3 / annum at 15,000 Nm^3/hr of gas *(calculated value for next Pilot Plant Phase, higher than output from existing infrastructure)*	Treated wastewater may be utilised for irrigation purposes at 15,000 Nm^3/hr operation. At this time the small amount of water treated is sent to the condensate dam and allowed to evaporate therefrom. Currently no water is being treated, it is stored in the condensate dam and removed from site for recycling by an approved contractor and either recycled or disposed of at a licensed appropriate waste site (i.e. Holfontein).
Flue gas from flaring	190 tons/hr	Flare Stack or Majuba Power Station exhaust stack (via the pipeline to Majuba)
Solid sludge and particulates	3 tons per month	The solid sludge waste has and will continue to be disposed off site via a contractor to a registered disposal site. At this time the options are being investigated for the condensate sludge to be removed, recycled off site by a service provider, and the material then potentially used by Eskom as a boiler fuel. The investigation is ongoing and will be finalised separately.
Spent activated carbon	8,400 tons/annum	At this stage of the project it is likely that the spent activated carbon will be re-generated off site. The quantity of activated carbon that can be regenerated still requires investigation and therefore there will likely be an activated carbon waste associated with this regeneration process. This process forms part of the ongoing research investigation of the wider project.

2.2 UCG Pilot Plant Phase 1 Components

The critical components of the UCG Pilot Plant Phase 1 are detailed in this section along with their status (complete / dormant) and the date that the triggering EIA activity was commenced with.

2.2.1 Gas Treatment Plant

A simplified gas treatment plant (GTP) has been established on the farm Roodekopjes 67HS. The extent of this GTP is approximately 30 x 60 m and consists of the following components:

a) heat exchanger – cooling towers,
b) liquid separation vessels,
c) emergency gas flare stack – approximate height of 9 m, and,
d) auxiliary pumps, motors and other small equipment.

The status is given as completed with the date of commencement being prior to November 2009.

2.2.2 Existing Process Water (Condensate) Dam

The condensate recovered from the gas treatment plant and gas pipeline is pumped into a process water dam (12,000 m^3 in size). The construction of the process water (condensate) dam was completed in August 2007. It has been in operation since 2007 to present (May 2013). The dam capacity as of March 2012 had reached 98% capacity. In March 2012, to control the level of the dam, a decision was taken to carry out a limited off-site disposal at "THE OLD OIL MAN" in Krugersdorp was completed.

Air injection into the Majuba Gasifier was stopped in September 2011, and the system has been left in effective "shut down" (dormant) mode since this time. The dam, with off-site disposal when levels in the dam reach dangerous levels, is the only feasible option in the absence of proven re-use or recovery of the condensate.

The dam is lined and has monitoring wells in place to provide an early warning system. The specification of the liner is a 2 mm HDPE liner, and it should be noted that no leaks have been detected to date. The dimensions of the dam are as follows: outside perimeter = 89 x 69 m, inside perimeter = 74 x 54 m, depth = 2.5 m. This dam is within the gasifier unit 1 footprint (refer to **Appendix E**). UCG condensate from gasifier unit 1 (i.e. the existing operation) has been piped to this dam.

Due to its current location, which has been noted as potentially being in close proximity to a drainage line, the existing dam will have to be emptied and the condensate (which is not removed from the site) transferred to the new dam (once authorised – this consideration will take place in the parallel EIA process) via the filter plant (explained in more detail in **Section 2.2.5**). The position of the dam was previously noted by the wetland specialist as being within a wetland or at least within close proximity thereto, this is in the process of being cross-checked.

As it currently stands though for the foreseeable future when the dam is considered to be at an unacceptably full level, the liquid will be drained and removed from site by an approved service provider. The material will either be recycled or disposed of by the service provider at a licensed disposal site, or investigations are ongoing to determine whether the material can be recycled for reuse. The remaining sludge at the base of the dam must then be removed and disposed of at a hazardous waste disposal site.

If it should be required that the dam should be repositioned the dam would then be fully drained and once the existing dam is completely empty, it can be decommissioned and pending a soil and water contamination assessment, the site where the dam is currently situated can be rehabilitated. Rehabilitation will include the

removal of all remaining infrastructure, re-contouring, re-vegetating and then on-going monitoring of the existing boreholes to ensure that no residual, previously undetected contamination exists.

If the dam is in fact suitably positioned and thus may remain, it would need to be upgraded to include additional features such as overflow points for instance.

Note that the decommissioning and repositioning of the dam, if required, would however require authorisation in its own right and thus would either be considered in the parallel EIA process or in a separate application. The issue however cannot be further considered in this application as decommissioning would trigger the regulations and thus cannot be considered in terms of rectification.

To summarise, the condensate storage dam, 12,000 m^3 in size is situated within the Gasifier 1 footprint. This dam is holding condensate at this time. It is noted that due to its position which is noted as being close to a drainage line that the intention is to apply for permission to consider a new position for the condensate dam, along with alternatives to the dam (e.g. above ground tanks), along with mechanisms to make use of the condensate as a viable resource to be sold off (i.e. by-product) rather than being merely a waste stream. The old condensate dam will need to be decommissioned and the site rehabilitated after being checked for any potential contamination. Note that this process will form part of the on-going EIA for the Pilot Plant Phase 2 of the UCG process currently under consideration. Its current status is that it is completed, with a date of commencement given as July 2006.

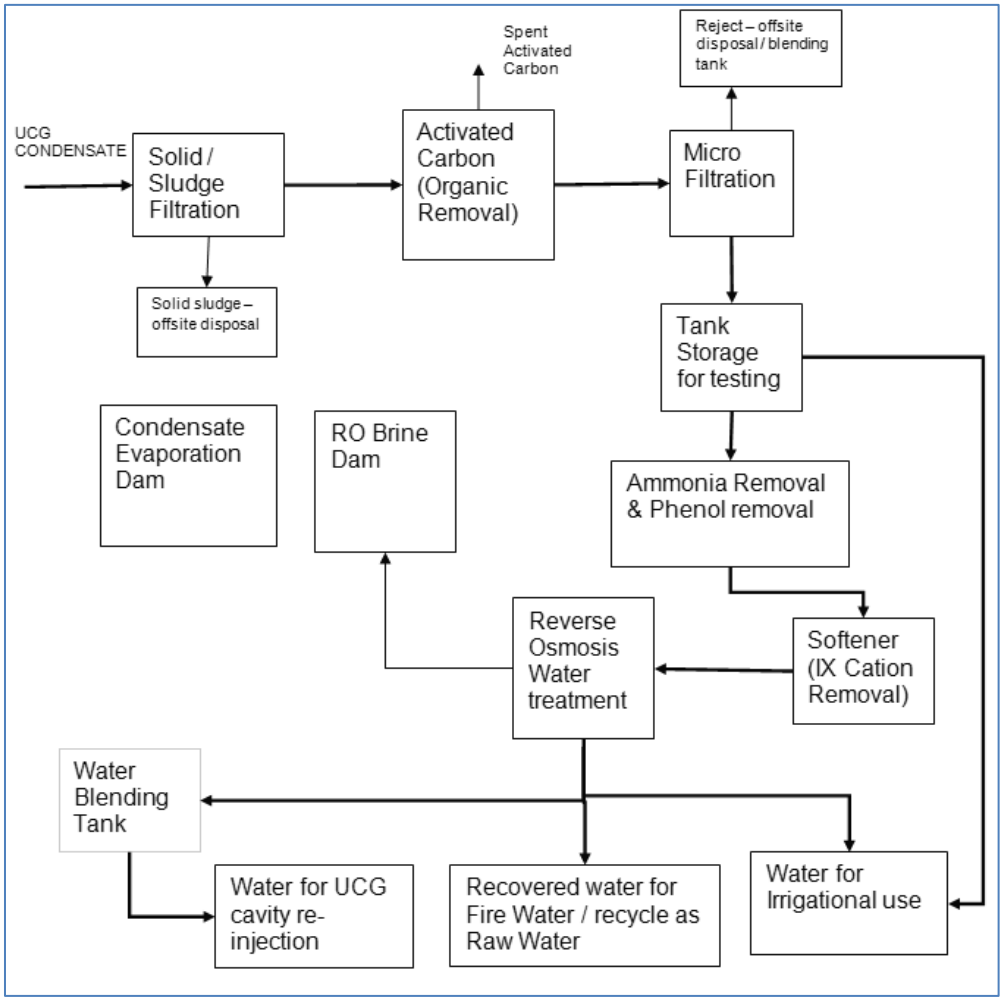


Figure 7: Water treatment plant system

2.2.3 Raw Water Dam

A raw water dam (approximately 3,000 m^3 in size) is also situated in the gasifier unit 1 footprint between the offices and control rooms and the compressor station. The raw water contained in this dam is not being utilised for any gasification-related processes, that is, it serves as an emergency water supply and for limited usage in dust suppression on access roads, drilling activities, flushing of water monitoring wells and Hydro braking (i.e. stopping combustion through dousing with injected water).

Note that the usage of water from the raw water dam forms part of the parallel water permit approval process.

The status for this activity is given as completed, with the effective date of commencement given as being prior to March 2006.

2.2.4 Water Tanks

Two (2) potable water tanks (approximately 10,000 ℓ in combined size) are located within the footprint of the gas treatment plant. The water from these tanks is used in the gas treatment plant cooling tower circuit (process cooling water make-up).

The water is sourced from the Majuba Power Station from its water treatment plants and allocated water resources.

These items are mentioned for completeness but do not trigger any listed activities in their own right.

2.2.5 Water Treatment Plant

The water treatment plant has been designed by SISTEMA AZUD, SA to treat 2,000 Nm^3/hr condensate (**Photograph 2**:). A block flow diagram of the plant is provided in **Figure 8**.

The condensate is pumped from the evaporation pond to the water filtration system (WFS) and enters the system at the pre-filters where the particles are removed by a 200 µm membrane. The pre-filters are backwashed periodically when a differential pressure of 0.8 barg is reached. The condensate then enters the granular activated carbon filters, which are placed in parallel, for the removal of organic constituents. The final treatment step is where the condensate is passed through the ultra-filtration (UF) membrane for the removal of molecules bigger than 0.2 µm. The UF membranes are set to backwash every thirty (30) minutes for a period of two (2) minutes.

The system is skid-mounted and will be tested and operated as soon as the licensing approvals are obtained. The product water during the testing will be returned to the condensate dam and not be disposed of in the environment. Any recovered hydrocarbons will be stored in existing storage tanks for off-site disposal. The objective is to prove via repeatable water analysis over an extended operational period that the condensate can be treated to an acceptable quality for possible re-use.

A water filtration plant with 2 x 23,000 ℓ (46,000 ℓ / 46 Kℓ, 46 m^3) tanks used for the separation of the water and waste. All infrastructure is within bund walls to prevent soil contamination in case of spillages.

Note that the status is given as completed with the date of commencement given as prior to March 2010.

Photograph 2: Water treatment plant

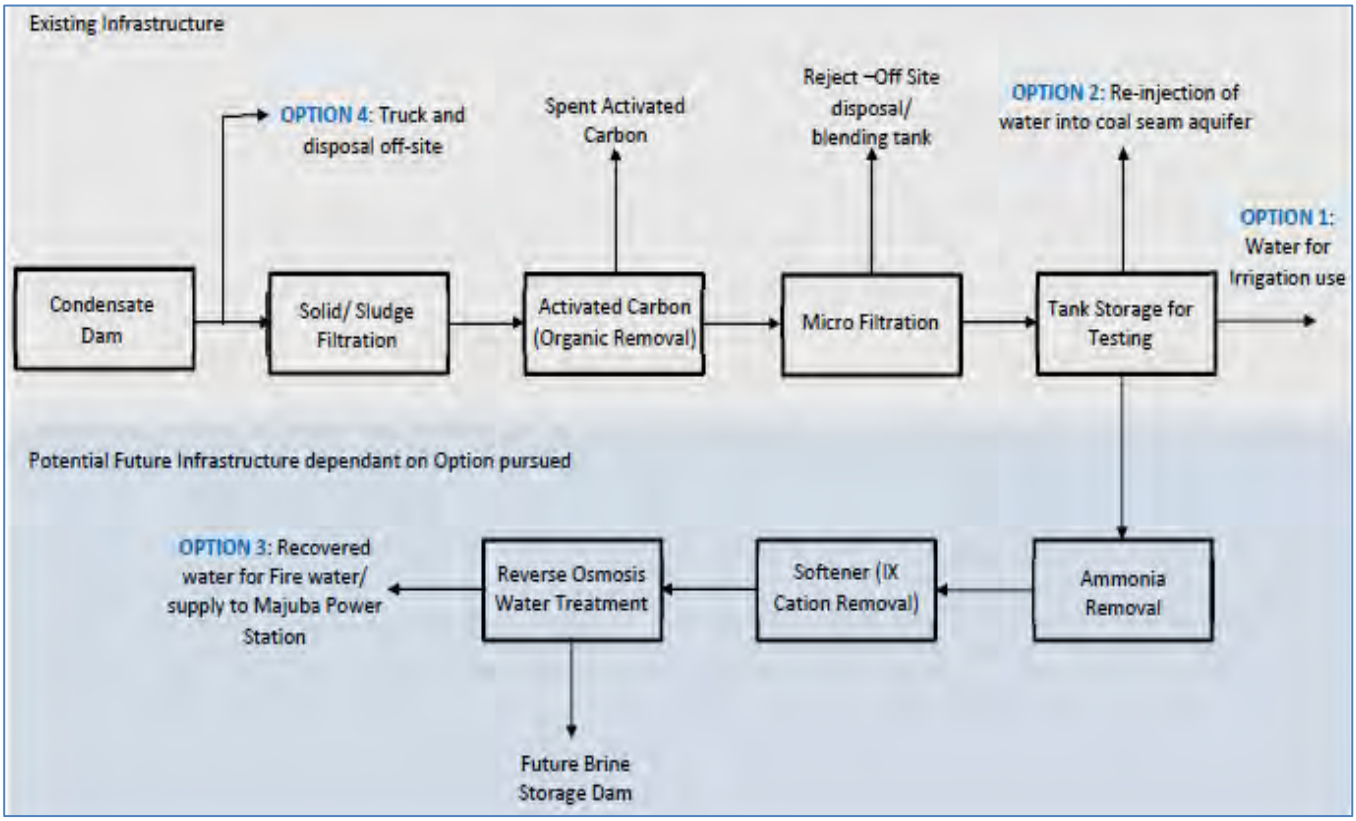


Figure 8: Block flow diagram for water treatment

2.2.6 Linking / internal pipelines

Pipelines internal to Gasifier 1 site were developed to allow for collection of the gases from the process and to facilitate the movement of water used in the process. The issue is that these pipelines cross one (1) perennial stream and one (1) river. The pipes were continuously built as the project developed – commencement is thus given as from July 2005, with construction running from then until January 2007.

Note that the main pipeline running to Majuba power station was previously approved by MDEDET in the form of an Exemption process. That pipeline is thus considered separately from the piping within the Gasifier footprint area.

The status of these internal pipelines is given as completed, with the date of commencement as being 2006 (between July 2005 and January 2007).

2.2.7 Access / Gasifier Roads

Internal access roads have been constructed in order to provide access to the development areas, in accordance with Eskom's phased development approach for UCG.

A description of the internal road infrastructure is presented in **Table 15** overleaf.

Table 15: Internal road infrastructure

Road Type	Characteristics of the Road and Associated Road Reserve
Secondary Roads	One lane gravel road surface lined with agglomerated stone or brick. Roads are located between the primary access roads and specific infrastructure components such as a gasifier unit. Secondary roads have and continue to be commissioned / decommissioned when required or if the road is no longer in use. The trigger of more than 1 km in length is noted and will be used as the rule of thumb for when a new application or an amendment will be needed (if not already approved).
Tertiary Roads	One lane gravel road for internal access within the footprint of infrastructure components such as internal roads within the gasifier unit and gas treatment plant. Roads will be decommissioned if the associated infrastructure is decommissioned by Eskom, for the specific phase of the development.
Bridges associated with Watercourse Crossings	Bridge structures were designed in such a manner to allow for adequate surface water flow and speed without causing additional erosion. All watercourse crossings shall hereafter be authorised under the Integrated Water Use License for UCG operations. Note that it is requested that the existing bridge over the river be allowed to be reconstructed due to the flood-related damage.
Fire Breaks	Fire breaks will be constructed around all existing operating infrastructure in order to protect the infrastructure against nature grassland fires. The fire breaks will have a width of 50 m and be clearly marked on all site layout maps.

Internal gravel access roads are used to access existing infrastructure (e.g. gasifiers) associated with the UCG pilot plant as it exists.

Note that the previously existing provincial road where it crosses the farm, the internal farm access roads remained in use with maintenance and enhancement (i.e. surfacing but not significant increase in width) thereof carried out. The length of the new roads on the site is approximately 6,770 m (6.7 km) in total.

Note that the pre-existing main access road (± 6,550 m (6.55 km)) and short section to the existing farmhouse (± 330 m) pre-dated Eskom's ownership of the site. The roads cross four (4) watercourses, namely, three (3) perennial streams and one (1) river.

The status of this activity is given as completed, with the date of commencement being from 2008 – 2010 (i.e. progressive addition and usage over the total time period).

2.2.8 Borrow Pit

Ground excavated from this area was used to fill up an old borrow pit on the same portion of the farm Roodekopjes, and, for the construction of gasifier roads. The remediated borrow pit thus pre-dated the presence of the UCG project on the farm. It is assumed that the original borrow pit filled was developed by the Provincial

authorities when constructing a regional road in the area. The approximate size of the existing borrow pit on the site is approximately 140 x 180 m (i.e. 25,200 m^2 ~ 2.5 ha).

The status is given as completed, with the date of commencement given as January 2008.

2.2.9 Hazardous substance storage

Bulk diesel storage tanks 2 x 23,000 ℓ (2 x 23 m^3 / 46 m^3) located in a bunded area. The tanks provide fuel for on-site vehicles and machinery.

The status is noted as completed as the tanks are on site and have been commissioned since February 2010.

2.2.10 Electrical Infrastructure

Bergvliet sub-station is an existing 88 kV to 22 kV substation owned by Eskom Distribution. From this substation the UCG project has had a 22 kV power line installed by Eskom Distribution along the servitude of the old coal conveyor from the Majuba Colliery to Majuba Power Station. This power line runs past the site of the Gas Treatment Plant where there are three take off points. From here, it runs to the gas field where there is a take-off point to the compressor plant and the control room. The line then continues to the existing farmhouse that is used as the site office, workshops and stores.

Along the north of the site is the servitude for the Ermelo to Majuba Power Station rail line. Within this servitude there will be an 88 kV power line supplying the traction substations for the rail. There will be two 88 kV power lines from this line forming a turn-in to the proposed High Voltage Yard to be built at the gas turbine generating set. Note that is a totally separate EIA process and only mentioned to contextualise the application at hand.

2.2.11 Other Infrastructure

Additional infrastructure includes all the components associated with UCG operations but not specifically associated with one of the major operating sections of the plant.

Due to the existing pilot plant operations, Eskom has a few other partly developed infrastructure items that is summarised in **Table 16** below, and shown in **Figure 9** overleaf.

Table 16: Existing infrastructure associated with the UCG pilot plant operations

Infrastructure	Description
Site Offices	There are two (2) existing site office locations at the UCG site. • Site office 1 is an old farmhouse that was refurbished as offices. Additional workshops were constructed at site office 1 for storage of operating machinery and vehicles. • The existing mining offices on the farm Bergvliet 65HS (portion 21) have been also been converted into site offices – indicated as Site Offices 2 in **Figure 9**. • In the 1990s underground mining activities commenced on the farm Bergvliet 65HS. After a few years, the mine was closed due to the quality of the existing coal seam as well as mining difficulties. Eskom purchased the existing infrastructure including the offices, workshops and Waste Water Treatment Works (WWTW).
Site Access and Security	Eskom requires strict site and security access at all power generation facilities. The same access and security points are implemented at the UCG pilot plant site.

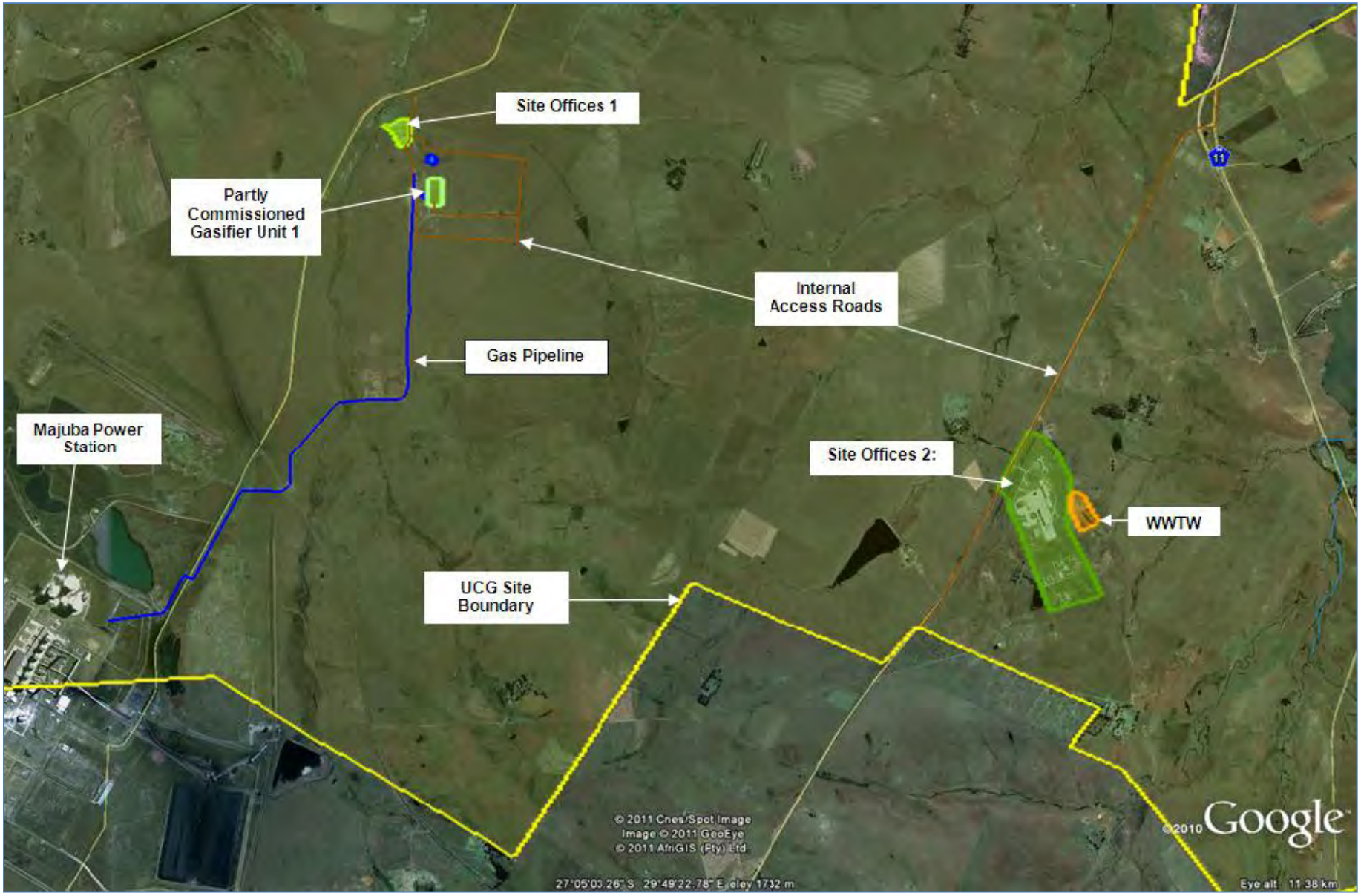


Figure 9: Existing infrastructure associated with the UCG operations (i.e. Pilot Plant Phase 1)

3 PROJECT ALTERNATIVES

In terms of the EIA Regulations, Section 28 (1)(c) feasible alternatives are required to be considered as part of environmental investigations. In addition, the obligation that alternatives are investigated is also a requirement of Section 24(4) of the National Environmental Management Act (No. 107 of 1998) (as amended).

An alternative in relation to a proposed activity refers to the different means of meeting the general purpose and requirements of the activity (as defined in Government Notice R.543 (GNR 543) of the EIA Regulations, 2010), which may include alternatives to:

a) the property on which or location where it is proposed to undertake the activity;

b) the type of activity to be undertaken;

c) the design or layout of the activity;

d) the technology to be used in the activity;

e) the operational aspects of the activity; and

f) the option of not implementing the activity.

In the case of a rectification process, the alternatives are much simpler, that is, ~~"n~~o go" (i.e. decommission and rehabilitate) or allow the existing scenario to proceed potentially with some modifications.

3.1 Do-nothing Alternative

Electricity cannot be stored in large quantities and must be used as it is generated. Therefore, electricity must be generated in accordance with supply-demand requirements. The demand for electricity in South Africa is currently growing. This growing electricity demand is placing increasing pressure on Eskom's existing power generation capacity. South Africa is expected to require additional peaking capacity (i.e. times of peak demand for electricity) and base-load capacity in the medium- to long-term, depending on the average growth rate. This has put pressure on the existing installed capacity to be able to meet the energy demands into the future, particularly during peak electricity demand times.

South Africa is endowed with 32 billion tons of coal reserves, which are rated as economically extractable, and a further 160 billion tons of coal resources, which are judged uneconomic to mine. Until fairly recently, there was little prospect of exploiting this enormous pent-up energy potential.

UCG technology could potentially unlock this energy resource, which was developed commercially in the former Soviet Union and is now being tested locally. The UCG process has been commercially proven on several sites in the former Soviet Union, and a pilot plant operated successfully from 1999 to 2003 in Chinchilla, in Australia. Moreover, the UCG technology in combination with a combined cycle power station will:

- Increase the overall resource utilisation efficiency (**Figure 10**) especially when the gas is used for power generation in a combined cycle power station. UCG as a mining technology also effectively extends South Africa's coal reserves, by allowing the extraction of coal previously disregarded as being un-mineable.
- Enables Eskom to position new coal generating plant far more strategically, to support demand side needs and stabilise the transmission network through the broader geographic availability of coal suitable for UCG.

- Increase Eskom's operational flexibility and efficiency, by allowing the coal mine and power station to effectively integrate.
- On a large scale, offers the opportunity to reduce the cost of electricity from new coal-based power stations. It achieves this through an inherently simpler mining process, and a shorter resource-to-electricity production supply chain.
- The UCG technology is modular, and Eskom has already pioneered the basis of the first module. The modularity, availability and relative simplicity of major plant components enables faster lead times than for conventional coal plants.

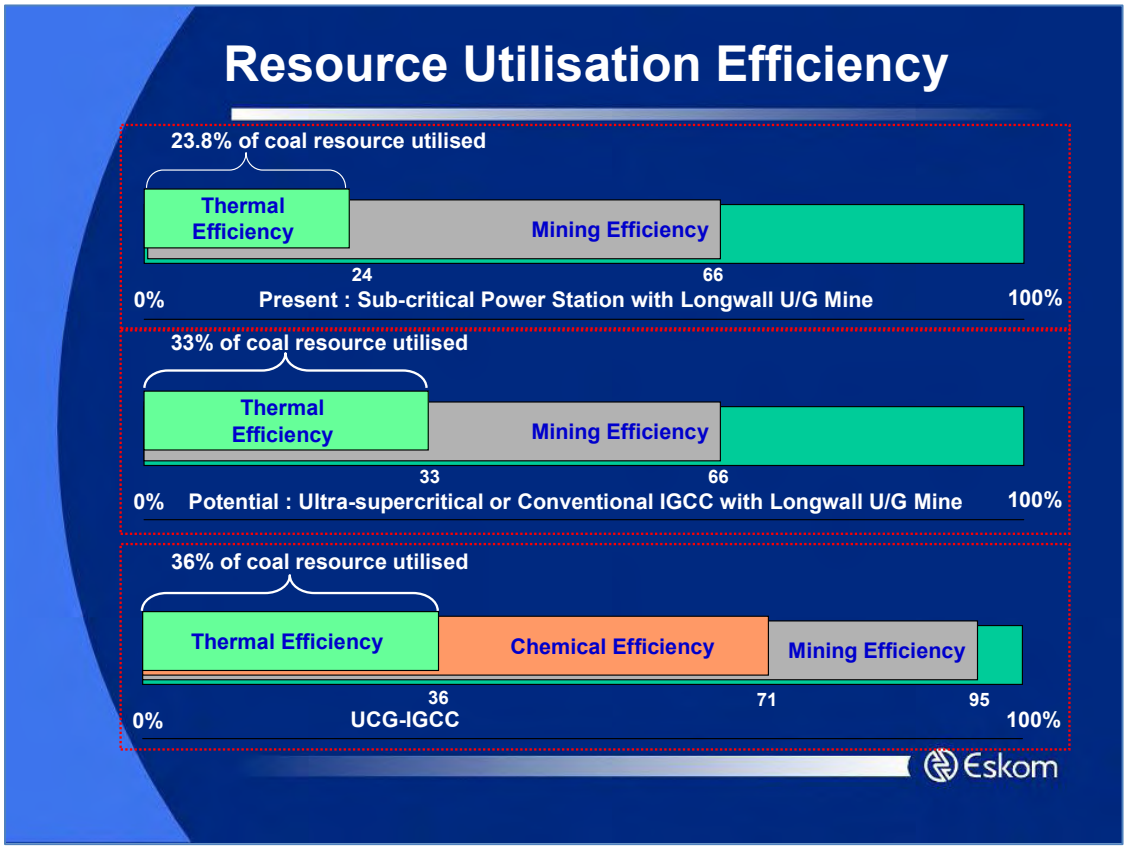


Figure 10: Resource utilisation efficiency

The ~~d~~o-nothing" option will contribute to Eskom not being able to fulfil its mandate to promote the energy mix and meet the projected growth in demand for electricity. This has serious short to medium-term implications for socio-economic development in South Africa.

3.2 Mining Options / Alternatives

There are two proposed alternatives associated with the implementation of UCG technology and will be further assessed in this Environmental Impact Study.

The location of the gasfield in Alternative 1 is linked to pre-determined gasfield compartments see coordinates in **Table 17**, within the farm Roodekopjes 67HS (Portions 1, 2, 3 and remaining extent).

No site alternative is available as the site is already in existence.

Table 17: Gasifier Coordinates

Gasifier Name	Position	Coordinates	
GASIFIER 1	NW CORNER	29° 48' 5.04" E	27° 3' 43.22" S
	NE CORNER	29° 48' 35.21" E	27° 3' 46.20" S
	SE CORNER	29° 48' 33.59" E	27° 4' 8.21" S
	SW CORNER	29° 48' 3.43" E	27° 4' 7.41" S

3.3 Water Treatment Alternatives

A number of options for the treatment of condensate exist, however, additional treatment options would not be considered to be appropriate in terms of the rectification process as these would trigger the need for new listed activities. As such treatment at this time remains treatment as feasible by the existing water treatment plant and then pumped to the condensate dam, with disposal off site.

The various alternate water treatment options however form part of the on-going EIA process and the future research options. As such, no water treatment alternatives are considered as viable other than the existing water treatment plant and the condensate dam.

The intention to decommission and remove this dam (as part of the parallel EIA process) does not change the fact that the dam exists and that to remove / decommission it an environmental authorisation process other than the rectification process would be required. As such the decommissioning can thus not be considered as a viable alternative in this specific case as it needs to be specifically considered.

Currently the water is held in the condensate dam and when a set threshold is reached, the condensate is pumped out and removed for disposal at a licensed waste site by a licensed service provider. A water treatment plant does exist, but has not been used aside from initial tests. Should the condensate dam remain for the foreseeable future, the water treatment plant will need to be brought up to full functionality so as to minimise the amount of waste removed from the site.

Currently, as noted above, the condensate is currently being trucked away and disposed of at a licensed waste disposal site. This option is an interim measure. Further options will form part of the on-going research investigations.

4 DESCRIPTION OF THE RECEIVING ENVIRONMENT

4.1 Biophysical Environment

4.1.1 Locality

The proposed project is located on the farm Roodekopjes 67HS. The project will take place on Portions 1, 2, 3 and remaining extent of the farm Roodekopjes 67HS (Eskom-owned).

Portion 4 of the farm Roodekopjes 67HS is privately owned and is not included as part of this assessment.

The total extent of the greater study area for all potential UCG activities planned is 2,449 ha. The rough footprint of the activities forming part of the rectification at hand is in the region of 100 ha.

Ancillary infrastructure such as a wastewater treatment works and site offices are located on Portion 21 of the farm Bergvliet 65HS. These items are not included in the rectification application as they were in existence when

Eskom bought the Bergvliet site prior to the start of the process, and are merely mentioned for completeness. It should further be noted that they were built as part of the mine infrastructure which was closed in 1992, thus the construction date (approximately mid-1980s) is significantly prior to 1997 and the first EIA regulations commencement date.

The Majuba Power Station is located south-east to the existing operations on Portion 1 of the farm Roodekopjes 67HS. The current land uses are mainly agricultural (Roodekopjes as well as immediate surrounding farms), mining (UCG pilot plant and Majuba Power Station), as well as industrial (Majuba Power Station as associated infrastructure).

The proposed project falls in the Mpumalanga Province in Ward 7 of the Pixley ka Seme Local Municipality (MP304) within the Gert Sibande District Municipality (DC30). The Pixley ka Seme Local Municipality is situated on the eastern border between Mpumalanga and KwaZulu-Natal. Furthermore, the municipal area is framed by the Mkhondo Municipality in the east; Msukaligwa Municipality to the north and Lekwa Municipality to the west (refer to **Figure 11**).

Pixley ka Seme Local Municipality comprises an area of approximately 5,227.98 km² which includes the following major urban areas or towns: Amersfoort, Ezamokuhle, Perdekop, Siyazenzela, Volksrust, Vukuzakhe, Wakkerstroom, and, eSizameleni. Other residential areas include Daggakraal Ext 1, 2 and 3, as well as Sinqobile A, B, C, and D.

Figure 11: Map indicating the Pixley ka Seme Local Municipality and surrounding municipalities

4.1.2 Regional and Local Climate and Atmospheric Dispersion Potential

The information presented in the subsections follows detail of the dispersion potential of the area under investigation. Majuba has its own meteorological station. Comparison was made between data sourced from the Majuba pilot plant and data taken from the South African Weather Services.

The period wind rose for the Majuba site is presented in **Figure 12** and the period wind rose for the data sourced from the South African Weather Services is presented in **Figure 13**.

Wind roses comprise of sixteen (16) spokes which represent the directions from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories.

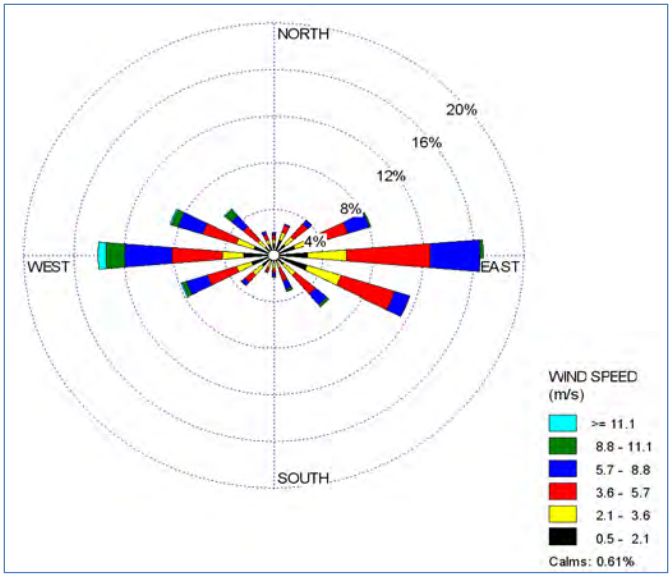


Figure 12: Period wind rose derived from monitored data from the Majuba pilot plant (2006 – 2007)

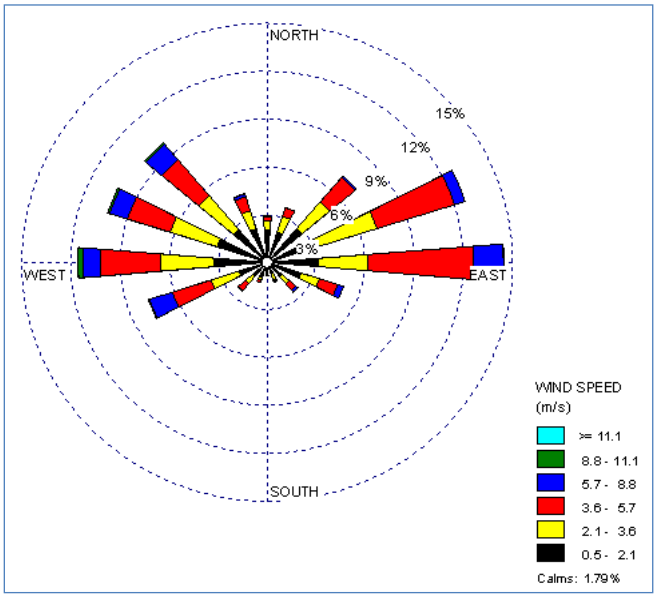


Figure 13: Period wind rose derived from modelled data sourced from the South African Weather Services (2006 – 2007)

For the period assessed, winds predominated from the western and eastern sectors. The wind rose profile is typical of that experienced by low-lying areas surrounded by an escarpment. From the eastern vector wind speeds of between 5.7 – 8.8 m/s occurred most of the time. The same wind speeds occurred but were less common from a south easterly and north-eastern sectors. Stronger winds of greater than 8.8 m/s were also experienced from the west. Smaller contributions of strong winds were also experienced from the west-southwest and west-northwesterly directions.

The average wind speed for the Amersfoort area is 3.24 m/s, with the highest recorded wind speeds (between 8 and 11 m/s) coming from the west. Of the annual modelled hourly data from the weather services, approximately 1.79% of that hourly data is recorded as calm winds, representing periods of little dispersion. Information pertaining to calm periods, average wind speeds and wind direction all play a significant role with regards to dispersion effects and will play a fundamental role during the modelling undertaken in the EIA phase of the project.

4.1.3 Atmospheric Stability

Atmospheric stability is commonly categorised into one of six stability classes. These are briefly described in **Table 18**. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5 – 6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Within the Majuba/UCG study area, very unstable to stable conditions predominates within most sectors, over the period 2007 to 2010. During this time period the most frequent stability class was Class F (Very stable) occurring 23.9% followed with Class C which occurred for 17.8% of the time (**Figure 14**).

Table 18: Atmospheric stability classes

Class	Class name	Descriptor
A	Very unstable	calm wind, clear skies, hot daytime conditions
B	Moderately unstable	clear skies, daytime conditions
C	Unstable	moderate wind, slightly overcast daytime conditions
D	Neutral	high winds or cloudy days and nights
E	Stable	moderate wind, slightly overcast night-time conditions
F	Very stable	low winds, clear skies, cold night-time conditions

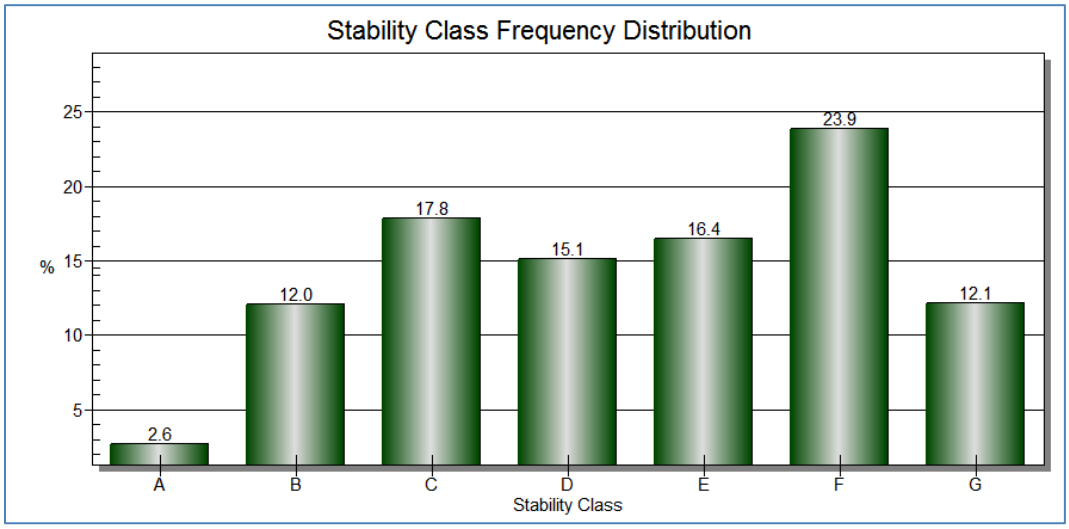


Figure 14: Stability frequency distribution for the Majuba site

4.1.4 Temperature and Humidity

As can be seen in **Figure 15** daily summer temperatures range between ~2 °C and ~32 °C with an average of ~17 °C. Winter temperatures range between ~-8 °C and ~23 °C with an average of ~7 °C.

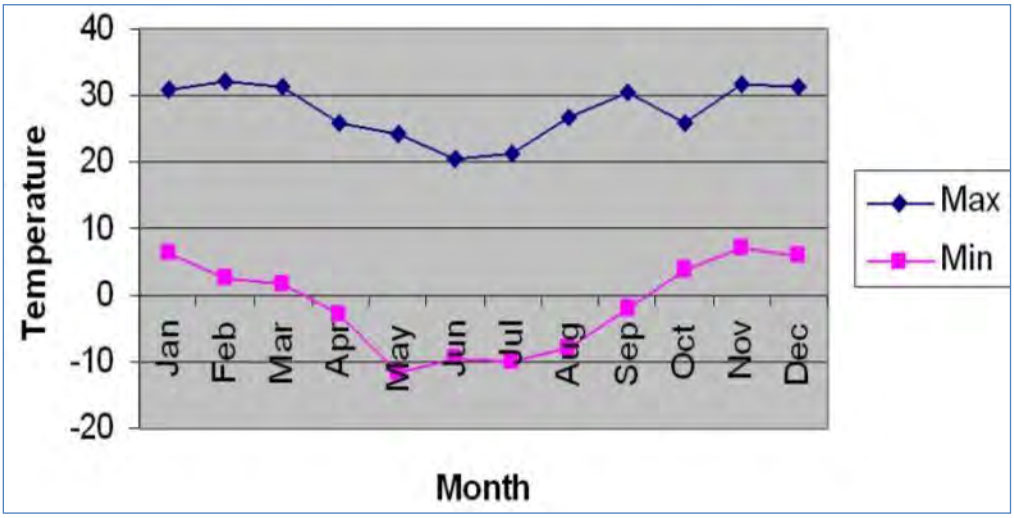


Figure 15: Average monthly maximum and minimum temperatures recorded in the Amersfoort region (SAWS station, 2007)

The study area experiences high relative humidity‘s during the summer months, with a couple of low relative humidity‘s months during winter (**Figure 16**).

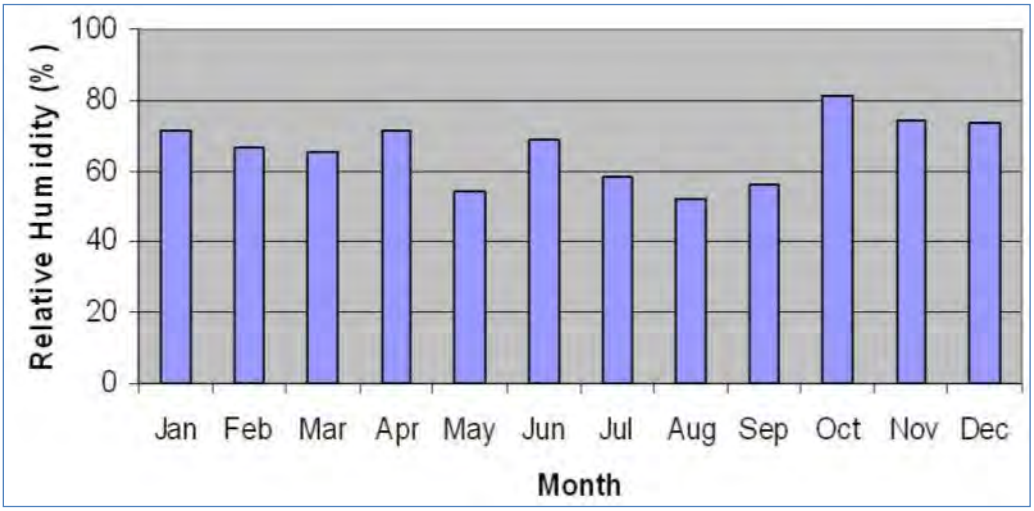


Figure 16: Average monthly relative humidity for the Amersfoort region (SAWS station 2007)

4.1.5 Topography and Landscape

The region is known for its rolling grass landscapes and the study area is a typical example thereof (**Photograph 3**). A basic analysis of topography and landforms revealed that the study area does not comprise sites where significant slopes are present. It should however be noted that the ENPAT database slope classes is based on a high contour interval. With the use of more detailed data, the identification of smaller areas of significant slopes will be made possible.

The topography of the general region varies between ‗*Slightly irregular undulating plains and hills*' and ‗*Strongly undulating plains*'.

Photograph 3: Greater study area showing the rolling grass landscape

4.1.6 Geology

4.1.6.1 Regional Geology

The majority of the study area is underlain by Karoo Supergroup sedimentary rocks of the Vryheid and Volksrust Formations of the Ecca Group. These are largely comprised of sandstone, mudstone, shale, siltstone, and coal seams.

The available geological maps covering the study area did not indicate any major structural features such as faults or fractures. Limited tectonic activity is recognised within the study area, and the only evidence of secondary processes is outcrops of intrusive younger dolerite sills mapped in the Karoo sediments.

Four generations of dolerite intrusions are recognised within the study area, based on olivine or plagioclase content, alteration, and texture. The intrusive dolerite has produced large-scale de-volatilisation and structural displacement of the coal. These adverse geological conditions caused the closure of the Majuba Colliery in 1993. The litho-stratigraphy of the study area is presented in **Table 19** below.

Table 19: Litho-stratigraphy of the study area

Age	Supergroup	Group	Subgroup	Formation	Lithology
Jurassic					Dolerite
Permian	Karoo	Ecca		Volksrust	Mudstone, siltstone, shale
Permian	Karoo	Ecca		Vryheid	Sandstone, siltstone, shale, coal

4.1.6.2 Geology of the farm Roodekopjes 67HS

The general geology of the farm Roodekopjes 67HS from surface downwards is illustrated in **Figure 18**.

The B8 dolerite sill outcrops at surface on the site and averages in the order of 30 m thick. A sandstone and siltstone interval of between 5 and 25 m is followed by two to three stages of sill intrusion of the B4 dolerite totalling approximately 120 m in thickness.

Below this composite dolerite sill are sequences of sandstones, siltstones and mudstones containing minor coal seams. The main coal seams namely the Alfred and Gus seams are at an average depth of 280 m below surface.

They total about 5 m in thickness with a small parting between them that thickens and becomes more prominent towards the east.

Below this is a sequence of bioturbated siltstones, sandstone and mudstone with minor coal seams.

The B6 dolerite sill underlies the whole farm. This dolerite has indurated the coal and the coal seams volatile content is well below the required average for Majuba Power Station. The seam elevation and altitude for farm Roodekopjes is flat and consistent.

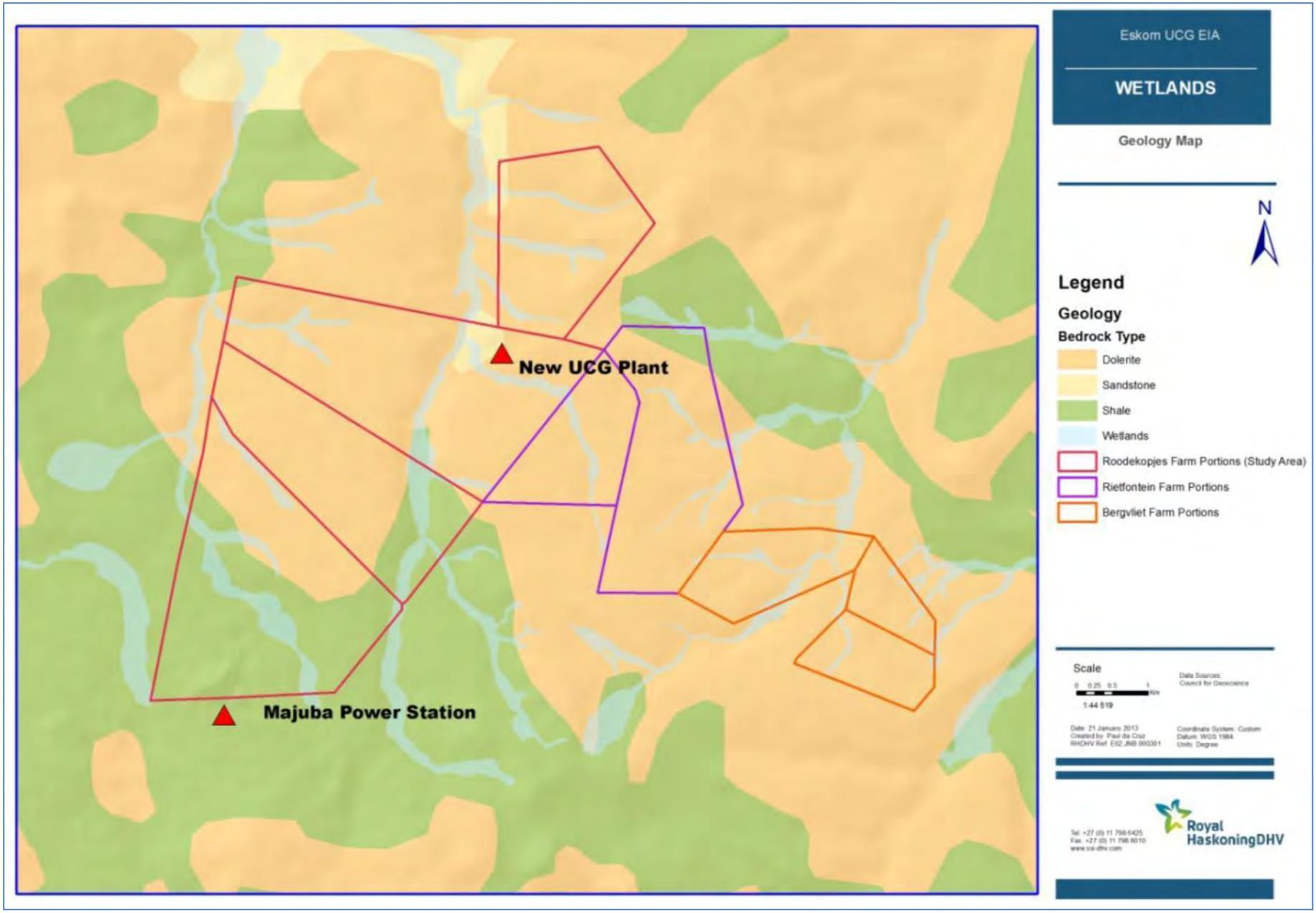


Figure 17: Study area geology

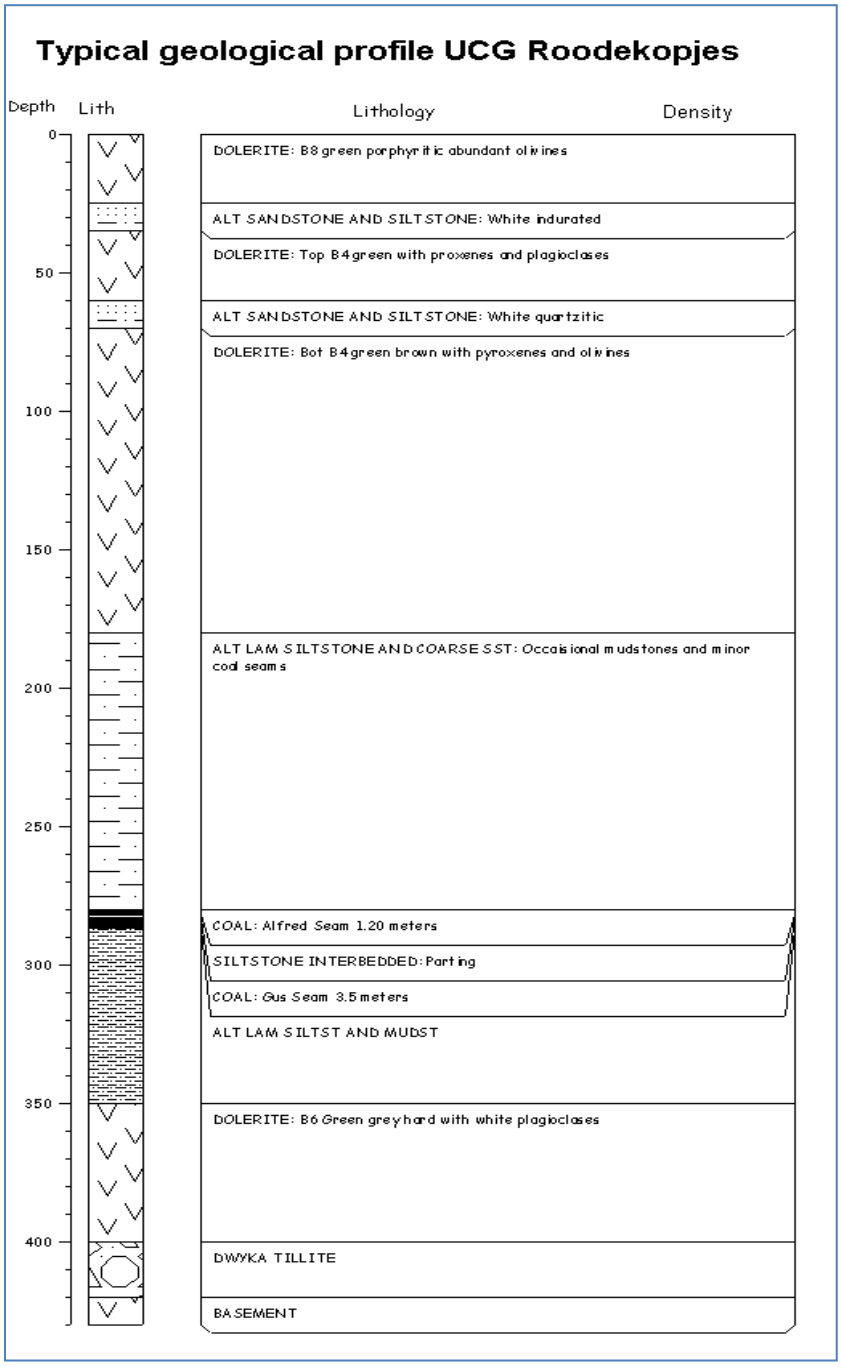


Figure 18: Typical geological profile of the farm Roodekopjes 67HS

4.1.6.3 Coal Seams

The two (2) main coal seams on the farm Roodekopjes 67HS are the Alfred and Gus seams. The Alfred seam varies between 1 and 1.5 m in thickness. It often has contaminated coal and sandstone near the top. The coal is a dull bituminous coal, high in ash with some carbonaceous shale bands. The coal is slightly devolatilised as shown by the range of dry ash free volatiles.

The Gus seam is separated from the overlying Alfred seam by a shale parting of coaly shale that becomes thicker and more carbonaceous to the east. The Gus seam averages over 3.0 m in thickness and is divided into a poor shaly top half and a high quality bottom half. Again the coal shows signs of de-volatilisation.

4.1.7 Hydrogeology

The UCG site is underlain by Karoo sediments. These comprise out of inter-bedded sequence of sandstones, mudstones and coal seams. The Karoo sequence is characterised by dolerite intrusions. At Majuba the sequence has been intruded by two dolerite sills. The upper sill, the B5, extends from approximately 70 m depth to about 170 m depth. The B6 sill lies about 50 m below the Gus coal seam (280 m below surface) at the Majuba UCG site.

A conceptual hydrogeological model was developed by Golder Associates Africa in 2010 and was updated in 2012 and is summarised below. The conceptual model (**Figure 19**) distinguishes between four distinct groundwater systems that are present at the UCG site.

4.1.7.1 Shallow Aquifer Unit

The shallow aquifer is found from surface to an average depth of 70 m below surface. This aquifer is present above the lower B4 dolerite sill and comprises weathered/fractured Karoo sediments and the upper B4 dolerite sill. Very low blow yields were encountered during drilling in this aquifer. The hydraulic conductivity ranges between 1.7 x 10^{-1} to 8.6 x 10^{-3} m/day. The groundwater piezometric levels vary between 17 and 35 m below surface and generally follow the topography.

The quality of the groundwater in the shallow aquifer is characteristic of recently recharged water and generally conforms to the SANS 241 Water Quality Guidelines for domestic use.

4.1.7.2 Intermediate Aquifer Unit

The previously defined intermediate aquifer zone is divided into an:

- *Intermediate upper aquifer zone*

  The intermediate upper aquifer zone (+/-70 to +/- 170 m) constitutes out of the top contact of the B5 dolerite sill. A hydraulic conductivity of 8x10^{-4} m/d was calculated for the intermediate upper aquifer zone.

- *Intermediate lower aquifer zone*

  The intermediate lower aquifer zone (+/-180 to +/- 270 m) constitutes bottom contact of the B5 dolerite sill including the sugary dolerite zone and the geological sedimentary units above the coal seam. Transmissivity values of the intermediate lower aquifer zone range from 0.1 to 0.9 m^2/d.

The SRK report of 1984[3] suggests hydraulic conductivity of 3x10^{-3} – 5x10^{-4} m/d for the average value across the aquifer and 3x10^{-4} – 5.5 m/d for the running (sugary) dolerite.

4.1.7.3 Coal Seam Aquifer Unit

The coal seam aquifer constitutes the fractured Gus coal seam and potential partings within the coal at depths between ± 280 and 284 m below surface. Groundwater levels measured in the deep monitoring boreholes range between 40 and 100 m below surface with recharge from overlying intermediate aquifer.

Golder confirmed the hydraulic conductivity as 10^{-4} m/day in 2007 and 10^{-5} m/day during 2012.

[3] ***Steffen Robertson & Kirsten, 1984***. *Report CI.3936/3: Majuba Coal Mine. Hydrogeological, Hydrological and Environmental Study. Summary Report*

4.1.7.4 Lower Aquifer Unit

A lower aquifer is assumed to be present below the Gus coal seam at depths below 284 m below surface.

No information regarding piezometric levels hydraulic properties is available but it can be assumed the hydraulic conductivity will be low.

Table 20: Hydraulic Parameters of Groundwater Conceptual Model

Groundwater zone	Distribution	Depth	Hydraulic Parameters (Hydraulic Conductivity (K) /Transmissivity (T))	Properties
Shallow groundwater zone	Throughout Majuba area	0 – 70 m below surface	K = 1.7 x 10^{-1} m/day – 8.6 x 10^{-3} m/day (Slug test done during the current study)	• Highly weathered/fractured dolerite and Karoo sediments • Permeability generally decreases with depth • Groundwater piezometric surface generally follows the topography • High ground between watercourses generally constitutes recharge areas • Watercourses and springs are discharge areas
Intermediate upper groundwater zone	Throughout Majuba area. (may be compartmentalized through dykes)	70 – 120 m below surface	K = 8.0 x 10^{-4} m/day (Slug test done during the current study)	• Fractured dolerite • Permeability depends on the extent of fracturing • Recharge from overlying groundwater zone
Intermediate Lower groundwater zone	Throughout Majuba area. (May be compartmentalized through dykes)	180 – 270 m below surface	T = 0.1 to 0.9 m^2/d (Test pumping done during the current study)	• Fractured dolerite and Karoo sediments below the dolerite. • Discharge to local base level (Vaal River?)
Gus coal seam groundwater zone	Throughout Majuba area	280 – 284 m below surface	K = 1.0 x10^{-4} m/day to 1.0 x10^{-5} m/day	• Fractured coal and lithological partings within the coal seam • Groundwater levels approximately 100 mbgl during 2006-2007 and 40 – 60 mbgl in 2008 • Recharge from overlying groundwater zone • Discharge to local base level (Vaal River?)
Lower groundwater zone	Throughout Majuba area	284 m – unknown depth.	No information available	• Fractured dolerite and Karoo sediments below the Gus seam – Permeability depends on extent of fracturing - likely to be very low – Recharge from overlying groundwater zone – Discharge to regional base level (Vaal River?)

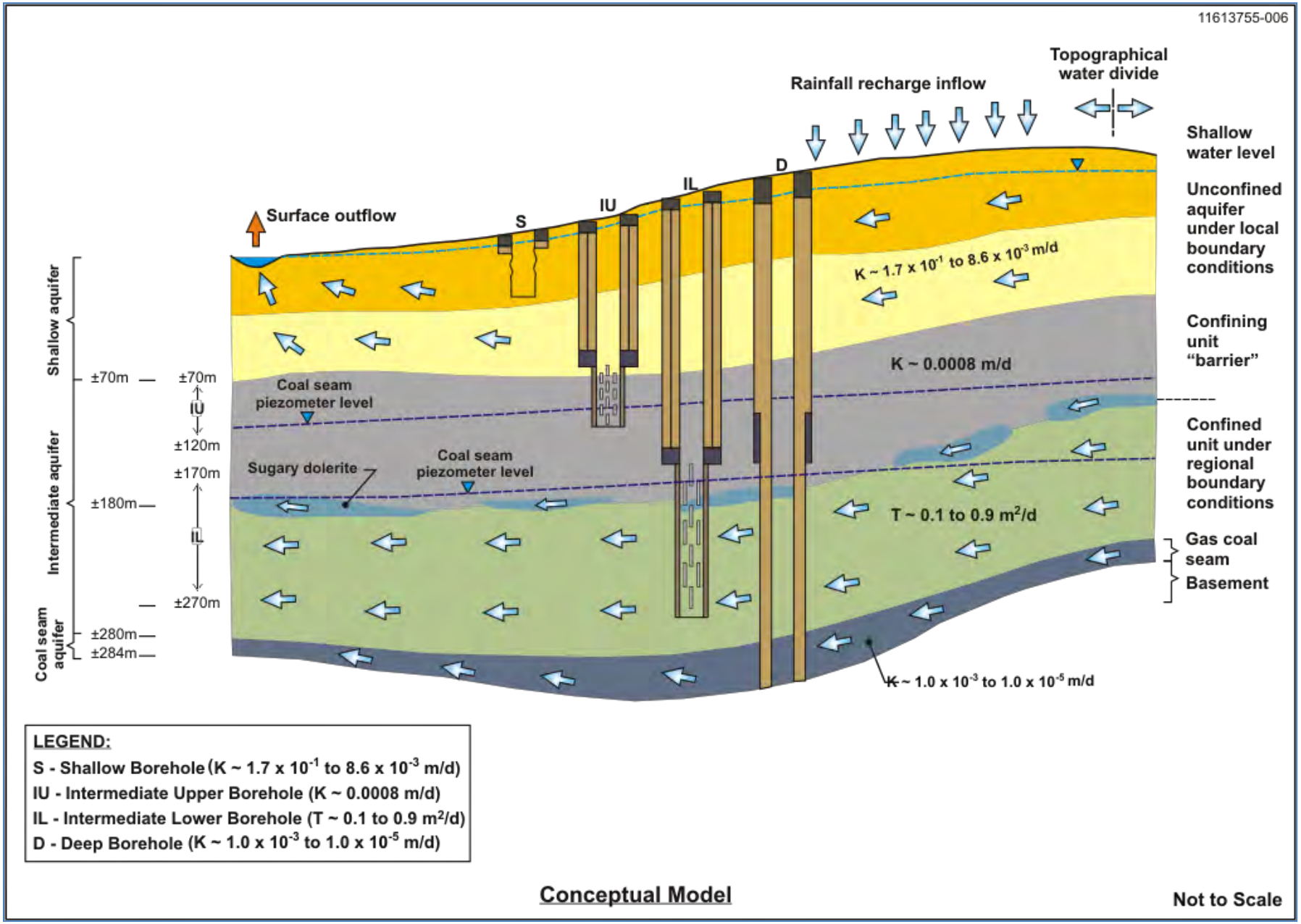


Figure 19: Conceptual hydrogeological model

The quality of the groundwater in the shallow aquifer unit is characteristic of recently recharged water and generally conforms to the SANS 241 Water Quality Guidelines for domestic use. There is a significant difference between the shallow aquifer unit and coal seam aquifer in terms of water levels and quality. This suggests that there is limited direct interaction between the two aquifers at the site although indirect interaction via the intermediate aquifer could occur. The saline character of the coal seam water does indicate a long underground flow path between recharge and discharge.

Groundwater hydrochemistry associated with the sediments is variable; the groundwater salinity associated with the formations in the study area can have electrical conductivity concentrations of < 250 up to 1,000 mS/m.

The sandstones of the Vryheid Formation of the Ecca Group can be massive and dense and have limited permeability and storage. It thus offers only moderate groundwater yield, especially in the absence of dolerite intrusions. Contacts between different rock lithologies and bedding planes within the sediments often yield groundwater. The contact zone between the dolerites and the sandstone lithologies can be high yielding. Fractured fault zones, especially if related to tensional stresses, are potentially rich targets for groundwater development. Groundwater occurs within the joints, bedding planes, and along dolerite contacts within the sediments (as recognised across the study area).

4.1.8 Hydrology

4.1.8.1 Drainage Context

The greater site straddles two quaternary catchments, both of which form part of the Grootdraai dam catchment of the Upper Vaal Water Management Area (WMA), C11J and C11E.

The area that is currently being assessed falls within catchment C11J, part of which is drained by the Witbankspruit, a stream that forms a tributary of the Upper Vaal River to the north of the site (the Witbankspruit flows from north to south across the site). All wetlands on the Roodekopjes site drain into the Witbankspruit.

The Upper Vaal WMA covers approximately 55,562 km^2 including parts of Gauteng, Mpumalanga, Free State and North West Provinces. It consists of the C1, C2 and C8 secondary drainage regions. The main rivers in the secondary drainage regions are listed in **Table 21**. There are three (3) large dams in the WMA: Grootdraai Dam, Vaal Dam and Sterkfontein Dam.

Table 21: Major catchments and rivers

Primary Catchment	Sub-catchment area	Quaternary catchments	Average gross area (km^2)
C	Wilge	C81A-M; C82AH; C83A-M	18,167
	Klip (Free State)	C13A-H	5,182
	Grootdraai	**C11A-L**	**7,995**
	Grootdraai to Vaal Dam	C11M; C12A-L	7,294
	Suikerbosrand	C12A-G	3,541
	Klip (Gauteng)	C22A-E	2,282
	Rietspruit	C22J and C22H	1,123
	Leeu / Taaiboschspruit	C22F; C22G; C22K	1,705
	Mooi	C23D-K	4,494
	Vaal Barrage to Mooi	C23A-C; C23L	3,239
	Wilge	C81A-M; C82AH; C83A-M	18,167

A small part of Roodekopjes property, and the Rietfontein and Bergvliet properties, fall within quaternary catchment C11E. The major rivers/streams in the area are the Skulpspruit (into which all wetlands located in this part of the site drain) and forms a tributary of the Rietspruit, itself a tributary of the Upper Vaal.

4.1.8.2 Water Users

The land-use in the area is primarily rural agricultural based, with an urban setting in the nearby town of Amersfoort:

a) Agriculture (covering the majority of the proposed development route);
b) Mixed urban use (in town approximately 7 km from proposed development area); and
c) Energy production (at Majuba Power Station opposite the proposed project area).

Amersfoort, Perdekop, Daggakraal, Siyasenzele and Ezamokuhle settlements falls under the management of the Pixley ka Seme Local Municipality in the Gert Sibande District Municipality.

The Pixley ka Seme Municipality serves as a Water Services Authority and Water Services Provider for the area. The Water Services Development Plan indicates that Amersfoort town main water source is the local dam (Amersfoort Dam) from where water is abstracted, purified and distributed. Amersfoort Dam is located on the Skulpspruit with a storage capacity of 0.992 million m^3 and a yield of 1.33 million m^3/annum. All water is abstracted from local resources.

The main water users in the area are therefore:

a) Urban related water users in the Pixley ka Seme Local Municipal area; and
b) Irrigation.

4.1.9 Wetlands

4.1.9.1 Study Area Biophysical Characteristics and how these relate to / affect Wetlands

- ***Geology***

The geological makeup of the area is important as it affects the geomorphological make-up of the landscape. This relates to the relative erodibility of the igneous (dolerite) rock as opposed to the sedimentary rock; dolerite is much more resistant to weathering than the sedimentary sandstones and weathers much more slowly. This has affected the landscape of the area in that the landscapes in the doleritic areas are slightly different from those in the areas of sedimentary geology. Where rivers and streams have to cross dolerite, in particular dolerite sills, the drainage has often cut relatively deep, narrow valleys into the landscape. This phenomenon is present to the west of the development site in the Palmietspruit valley where the river and its tributaries have cut relatively deeply incised valleys into the landscape.

Importantly, this has a critical bearing on the geomorphology of the drainage in this area as wetlands, where they exist are typically narrow, linear features that extend from valley bottoms up into the upper parts of valley heads. In certain areas underlain by dolerite geology, the valley bottom takes the form of a river channel rather than a wetland. In the tributaries of many of the larger streams in the area, wetlands in the higher valleys and valley heads are relatively narrow in width, many being less the 50 m wide. Wetland vegetation (see the ensuing sections for a description of wetland soils) is typically limited to the centre of the valley bottom into which a (stable) gulley has cut into the deep vertic soils.

This can be contrasted with wetlands on sandstone geology. The landscapes underlain by sandstone geology are typically shallower and less incised than those underlain by dolerite. As a result wetlands are typically wider, less channelized, and are much more likely to be characterised by areas of diffuse flow in which moribund vegetation often occurs. As soon as the wetland traverses dolerite, the wetland changes to become a much narrower wetland with limited patches of wetland soil and vegetation in the valley bottom.

It is important to note that all of the floodplain wetland units in the wider area (former study area) and on the revised development site occur on sandstone or shale geology. Many of the wider un-channelled valley bottom wetlands also occur in similar geology. These areas of sandstone or shale geology are typically surrounded by areas of dolerite geology and doleritic features such as dykes. The presence of these features is likely to be responsible for the formation of floodplain wetlands.

- ***Groundwater and Wetland Hydrology***

A report undertaken by Golder[4] for the study area around the first wells drilled (on the farm Roodekopjes) indicate that there are three distinct aquifers in the study area; a shallow aquifer (from surface level to approximately
70 m), an intermediate aquifer and a much deeper aquifer. The shallow aquifer is of importance in a context of wetlands, as the other two aquifers are too deep to have any hydrological connectivity to the surface. This shallow aquifer is thought to occur across the study area[5].

The report by Golder further indicates that groundwater flow patterns in the shallow aquifer mimic the topography; i.e. groundwater flows were observed to be directed towards the Witbankspruit valley bottom and valley bottom tributary to the east. The study found that the piezometric groundwater level follows the topography; i.e. groundwater levels are deepest on interfluves and shallowest in valley bottoms. In the area in which boreholes were sampled the piezometric groundwater levels were observed to be between 17 and 35 m below the surface. This mimicry of groundwater flows and levels to terrain entails that groundwater discharge areas would primarily be located in valley bottoms. Importantly in this way the Golder report concurs with the observation in this study that groundwater discharge into wetlands occurs in the upper parts of valley bottoms and valley heads.

The Golder report also states that interfluves are groundwater recharge areas. The presence of vertic soils that occur across most of the study area may be a limiting factor in the recharge of groundwater into the ground. These soils are highly impermeable when wet, and thus preclude the vertical movement of rainwater into the ground, with much rainwater being directed as overland flow into the drainage systems, rather than sub-surface flow.

- ***Soils and Land Types***

As the majority of the study area is underlain by dolerite, most of this area is associated with highly vertic soils. In these areas there is homogeneity of soil type along the catena, with the vertic soils being uniformly present from crest to valley bottom, irrespective of location within the landscape or location within or outside of wetland areas. This is unusual, as many parts of the Highveld are characterised by a distinct sequence of soil forms from the valley bottom (in which wetlands are located) to the non-wetland mid-slopes and up to the crest. The wetland soil forms in the valley bottom are distinct from the other soil forms in the non-wetland areas around, and

[4] ***Golder Associates; 2009***. *Majuba Underground Coal Gasification: February 2008 – March 2009. Report 11600-8209-1.*
[5] Ibid. *Footnote* 4.

upslope of them, and this allows the wetland areas to be differentiated from the non-wetland parts of the landscape. This is not the case in many parts of the study area.

Vertic soils are characterised by the presence of swelling and shrinking clays. They typically form where there is a distinct wet and dry period that affects the soils. These soils swell when they become saturated, and shrink again when they dry out, leading to characteristic ‗cracking' on the surface of the ground (**Photograph 4**).

Photograph 4: Cracking on the surface of vertic soils

Vertic soils, even those that appear in wetlands, do not typically display redoximorphic features in the form of yellow or red / orange mottles. This is due to their high (alkaline) ph ≥8. Thus the usual soil wetness indicators do not apply to many of the wetlands in the study area.

- ***Drainage and Catchments***

All wetlands and rivers on the site drain into the Upper Vaal River. This factor is relatively important in a catchment management context as the Vaal River is critical in the supply of water to South Africa's most densely populated area and economic hub i.e. Gauteng.

4.1.9.2 Wetland Characteristics

- ***Wetland Hydrogeomorphic Forms***

There are a number of different types of wetlands in the study area, including a number of different wetland hydrogeomorphic forms; a classification system exists for different types of wetlands – a hydrogeomorphic-based classification system. The wetland hydrogeomorphic (HGM) approach to wetland classification which uses hydrological and geomorphological characteristics to distinguish primary wetland units has been used to classify wetland types in South Africa[6]. This approach has been used, and the classification system has been recently updated as part of the National Wetland Classification System for South Africa[7].

[6] ***SANBI; 2009:*** *Further Development of a Proposed National Wetland Classification System for South Africa, Primary Project Report. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).*

[7] Ibid. *Footnote* 6.

Under this classification system there are a number of different types of terrestrial (as opposed to marine) wetlands, some of which occur in the study area:

a) Channel
b) Channelled Valley-Bottom Wetland
c) Un-channelled Valley-Bottom Wetland
d) Floodplain
e) Hillslope Seep
f) Valleyhead Seep

The only wetland HGM units that have not been identified in the greater study area is the ‗flat' wetland as well as the pan / depression wetland. A flat wetland is defined as a near-level wetland area (i.e. with little or no relief) with little or no gradient, situated on a plain or a bench in terms of landscape setting. Due to the undulating nature of the terrain in the study area, no flat or pan / depression wetlands have been found to occur.

The most common form of HGM form is the valley-bottom wetland, found in the numerous valley bottoms in the area. Most of these wetlands are naturally channelled, but importantly in a wetland functionality context, many are un-channelled and are characterised by diffuse (non-channelled) flow over the width of the wetland. The valleyhead seep wetland typically occurs at the head of valley bottoms where the terrain typically becomes steeper, rising out of the valley bottom. These HGM types are critical as they contain most of the seepage areas from which groundwater discharge is fed into the downstream wetlands / watercourses.

Floodplain wetlands are found exclusively on areas of sedimentary geology in the study area. These wetlands are important from a wetland functional point of view, as they have the ability to hold flood waters in depressions that would otherwise have flowed downstream and have a number of associated hydrological and ecological functions.

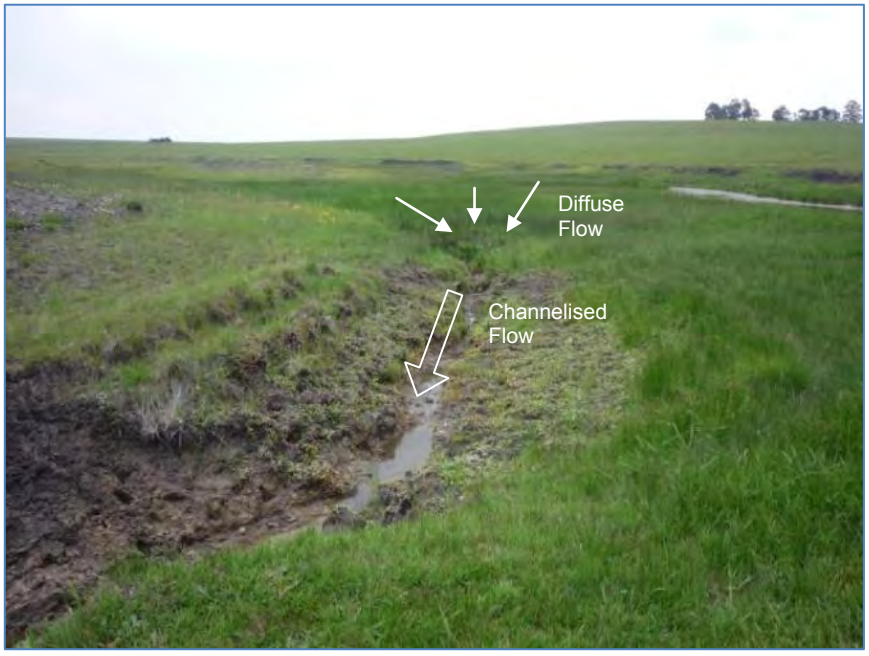
- ***Wetland Hydromophology (Hydrology and Geomorphological Processes)***

As described by the different hydrogeomorphic forms, different wetlands have different hydrological regimes. A key distinction can be made in terms of the surface hydrology of wetlands in the area, i.e. whether these are channelled or un-channelled. The majority of wetlands in the area contain some sort of channelled flow, sometimes in conjunction with diffuse flow. A large proportion of wetlands in the area are either valleyhead seep or valley bottom wetlands in which the bulk of the ‗wetland habitat' (i.e. distinct wetland plant species and saturated area) occurs within the confines of a relatively narrow macro-channel. This is most common in doleritic areas of homogenous vertic soils across the catena. Flow within these wetlands is strongly channelled, or if diffuse, across a very narrow width of between approximately 20 and 40 m. Most of these types of wetlands appeared to be morphologically stable, i.e. they were relatively well vegetated and did not display excessive erosion in their bed or banks. Many of these wetlands displayed a relatively low ‗scarp' erosion face at the top of the macro-channel bank.

Sub-surface flow is more complex, as this involves groundwater discharge. The vertic soils that predominate in the study area become relatively impermeable on becoming saturated. This means that sub-surface water is unlikely to move through the soils either vertically or on a horizontal plane (downslope), and the component of shallow sub-surface flow that it is an important component of the hydrological cycle in other parts of the Highveld is likely to be less important in this area (*pers comm.* Johan van der Waals). This would mean that water inputs to wetlands from upstream or the surrounding catchment during the wetter summer months would take the form of surface flows. Field assessments during, and immediately after a period of precipitation (on December 3, 2010 – rain had fallen in the area intermittently for roughly a 24-hour period) seemingly indicated this phenomenon. A

significant degree of surface water run-off was noted, not only in wetland areas, but in the surrounding grassland. This has implications for the hydrology of wetlands, as the hydrograph is likely to show a distinct increase in flows during and immediately after periods of rainfall, with a concomitant fall once the rainfall event has stopped. This surface sheet wash / run-off is likely to enter many of the channelled wetlands and be transported down the system. Only in wetlands where significant areas of wide, un-channelled wetland habitat (especially those areas containing moribund vegetation), and in those wetlands which have significant depressions would this flow be attenuated for longer periods.

Erosion has been observed in one form or another in most of the wetlands in the study area. The most commonly encountered form of erosion is the headcut, with an associated gulley (donga) downstream of it. Headcuts were observed in many wetlands, in particular valleyhead seeps where a soil profile exists, where the presence of bedrock outcropping tends to preclude erosion.



Photograph 5: Example of a headcut eating up into an area of diffuse flow

There is also evidence that cattle are contributing to the retreat back of channel banks. In many areas cattle trampling was evident on banks down which they move to cross or access channels. This leaves the channels exposed and mobilises the sediment, allowing it to be washed down the channel as silt. There is thus much evidence to suggest that cattle are contributing to the channelization of wetlands.

- ***Wetland Hydrological Zonation***

The nature of the soils and the hydrology of wetlands affects the hydro-period (period of saturation of soils) of wetlands in the study area. The soil characteristics make it difficult for this classical zonation to be applied to wetlands in the study area. As discussed above, many wetlands are characterised by vertic soils across their width (and into the wetland catchment). The nature of vertic soils entails that these soils typically experience distinct seasonal periods of saturation and drying out. Under these conditions, very few of the wetlands could thus be considered to have permanently inundated / saturated zones.

The occurrence of typical obligate hydrophytes such as *Phragmites australis* and *Typha capensis* (which are typically found in the permanent wetland zone) in the study area appears to be limited to areas characterised by sedimentary geology which are typically devoid of vertic soils.

The hydro-period in wetlands in which vertic soils predominate could be described more accurately as predominantly seasonal, with the vast majority of the width of the wetland being seasonally inundated, with a very narrow temporary zone. In some wetlands the temporary zone may be absent as there is an abrupt transformation between the (seasonal) wetland zone and the surrounding grassland. This is especially true where there wetland habitat is confined to the bottom of a macro-channel.

- ***Wetland Vegetative Characteristics***

The study area lies in the south-eastern part of the Mpumalanga Highveld where the grassland biome is predominant. Grassveld vegetation thus characterises the entire study area. Wetlands in the study area are largely grass and forb-dominated. Commonly occurring wetland grass species in the study area is presented in **Table 22**.

Table 22: Commonly occurring wetland grass species in the study area

Species	Hydrological zone / part of wetland
Agrostis lachnantha	Wetter areas (close to channels and in seepage zones)
Andropogon appendiculatus	
Andropogon eucomus	In seepage areas, especially sloping banks
Eragrostis plana	Across wetlands, especially in the drier parts of wetlands dominated by vertic clay soils
Helictotrichon turgidulum	Wetter areas (close to channels and in seepage zones)
Hemarthria altissima	Commonly inundated parts of valley bottoms, especially un-channelled valley bottoms
Imperata cylindrical	Seepage areas and river banks
Leersia hexandra	In seepage areas and in channel bottoms, especially in areas of standing water
Paspalum dilatatum	All parts of wetlands
Setaria sphacelata* var. *torta	Margins / drier peripheries of wetlands, or wetlands which are not regularly inundated
Themeda triandra	Margins / drier peripheries of wetlands, or wetlands which are not regularly inundated

In most wetlands where shallow water occurs, the grass *Leersia hexandra* was noted to be common, often forming large stands. This grass is important in a number of contexts as it forms the habitat for the Marsh Sylph butterfly (*Metisella meninx*) which is threatened in many parts of its range by habitat destruction.

The reed *Phragmites australis*, which is commonly encountered in many floodplain wetlands on the Highveld is not commonly encountered in many wetlands in the study area, in spite of the presence of suitable wetland habitat, especially within a number of valley bottom and floodplain wetlands. Where it is encountered, it typically occurs along the banks of rivers and streams, and in some cases in seepage areas.

The Vaal River Lily, *Crinum bulbispermum* occurs prominently in wetter inundated parts of wetlands and along stream banks. *Kniphofia fluviatilis* (River Poker) was found in a few wetlands in the study area.

Photograph 6: *Leersia hexandra* and a few *Crinum bulbispermum* specimens in a depression in the Witbankspruit floodplain wetland

4.1.10 Soils and Agricultural Potential

4.1.10.1 Land Type

The study area falls into the Ca2 land type (refer to the land type map of the study area – **Appendix J**).

A brief description of the land type is provided in **Table 23**.

Table 23: Characteristics of the Land Type Ca2

Soils	Land capability and capability and land use	Agricultural Potential
Landscape dominated by shallow yellow-brown apedal, distrophic soils in higher lying areas, variable depth bleached apedal soils in mid-slope positions and poorly drained structured soils of variable depth in low lying areas	Mainly dryland agriculture and extensive grazing	Medium to low except for lower lying areas that constitute wetlands

4.1.10.2 Soil Types

The topography of the broader site is undulating hilly and as such there are numerous low ridges and hills interspersed with drainage depressions and stream / drainage channels. The geology is dominated by dolerite (with inclusions of sandstone, grit and shale) leading to the dominance of shallow to moderately deep structured soils, often with vertic properties in lower lying areas and drainage depressions. These properties have far reaching implications for different land uses and aspects such as wetland delineation exercise as described in the sections that follow below.

The soils on the site can be grouped into three main categories or groups namely:

a) shallow and rocky soils on convex topography;
b) variable depth structured soils in flat terrain outside drainage depressions, and,
c) structured and swelling soils in drainage depressions (concave topography).

- ***Shallow and Rocky Soils on Convex Topography***

The area dominated by shallow and rocky soils is situated mainly on convex topography – that is rock outcrops, hills and ridges as well as vast areas making up the higher lying parts of the landscape.

The soils are predominantly of the Mispah (Orthic A-horizon / Hard Rock), Glenrosa (Orthic A-horizon / Lithocutanic B-horizon), shallow Arcadia (Vertic A-horizon / Unspecified – usually hard or weathering rock), Mayo (Melanic A-horizon / Lithocutanic B-horizon) and occasionally Milkwood (Melanic A-horizon / Hard Rock) forms. The texture of the A-horizons varies widely in that some are sandy (and sometimes bleached), some are clayey and some have very distinct structure.

During the survey it was found that there is very little predictability in the distribution of the different properties. This is a result of the varying geology as well as topography on the site.

Photograph 7: Shallow and rocky soils (rock outcrop)

- ***Variable Depth Structured Soils in Flat Terrain (Outside Drainage Depressions)***

The areas of flat terrain consist of a range of soils that vary from structured with swelling properties, to structured without swelling properties to sandy soil material overlying structured subsoils. The soils found in these areas do not occur in clear patterns and only a small degree of predictability is evident (as opposed to areas dominated by Plinthic Catena).

Soil forms include Arcadia (Vertic A-horizon / Unspecified – usually hard or weathering rock), Sepane (Orthic A-horizon / Pedocutanic B-horizon / Unconsolidated material with signs of wetness) and Tukulu (Orthic A-horizon / Neocutanic B-horizon / Unspecified material with signs of wetness) soil forms with occasional occurrences of Glenrosa (Orthic A-horizon / Lithocutanic B-horizon), Klapmuts (Orthic A-horizon / E-horizon / Pedocutanic B-horizon), Hutton (Orthic A-horizon / Red Apedal B-horizon), Clovelly (Orthic A-horizon / Yellow-brown Apedal B-horizon), Westleigh (Orthic A-horizon / Soft Plinthic B-horizon), Avalon (Orthic A-horizon / Yellow-brown Apedal B-horizon / Soft Plinthic B-horizon) as well as the shallow soils listed earlier.

Photograph 8: Organic rich Orthic A-horizon of a Tukulu soil form on site

- ***Structured and Swelling Soils in Drainage Depressions (Concave Topography)***

The drainage depressions also exhibited certain degree of soil form variability but one of the constant characteristics is the presence of swelling properties in the soils. The swelling properties imply that most of the soils in lower lying areas are dominated by smectite clay minerals. These clay minerals impart characteristics to the soils that manifest in the form of cracks and slickensides (**Photograph 9**).

Photograph 9: Distinct slickenslides in the G-horizon of a Rensburg soil form

These soils are often associated with lime rich subsoil horizons that, when exposed, are characterised by copious amounts of lime nodules (concretions) (**Photograph 10**).

Photograph 10: Lime nodules associated with eroded and exposed G-horizons in under Vertic (and sometimes Melanic) A-horizons

Some of the soils had high clay contents without swelling properties indicating the presence of non-swelling 2:1 clay minerals. Even though the soils are dominated by similar clay minerals they vary in terms of soil form due to the variability in depth, rockiness and recently transported or eroded soil horizons / material.

The soil forms are, amongst others: Rensburg (Vertic A-horizon / G-horizon), Arcadia (Vertic A-horizon / Unspecified – usually hard or weathering rock), Mayo (Melanic A-horizon / Lithocutanic B-horizon), Milkwood (Melanic A-horizon / Hard Rock), Willowbrook (Melanic A-horizon / G-horizon), Katspruit (Orthic A-horizon / G-horizon), Dundee (Orthic A-horizon / Stratified Alluvium) and Mispah (Orthic A-horizon / Hard Rock).

4.1.11 Vegetation

The study site corresponds to the Grassland Biome, more specifically the Mesic Highveld Grassland as defined by Mucina and Rutherford (2006)[8]. This unit is found in the eastern, precipitation-rich regions of the Highveld. Grasslands of these parts are regarded ‗sour grasslands'. The study area comprehends an ecological type known as the Amersfoort Highveld Clay Grassland. This grassland comprises undulating plains, with small scattered patches of dolerite outcrops.

The vegetation comprises of short, closed grassland, largely dominated by a dense *Themeda triandra* sward, often severely grazed. Overgrazing leads to invasion of *Seriphium plumosum*.

[8] ***Mucina, L. & Rutherford, M.C. (eds.). 2006***. *The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.*

Parts of this unit were once cultivated and these transformed areas are not picked up by satellite for transformation coverage; the percentage of grasslands still in a natural state may therefore be underestimated. The conservation status is regarded as ‗Vulnerable'; none is formally protected.

The study area is situated within a part of the African Grasslands / Ekengela Initiative Transition Zone, rendering all areas of natural grassland sensitive (ENPAT, National Database, Biosphere). Some 25% of this vegetation type is transformed, predominantly by cultivation (22%).

The area is not suited to forestation. Silver and black wattle and *Salix babylonica* invade drainage areas.

4.1.12 Terrestrial Biodiversity Categories on a Local Scale

The mandate for conserving biodiversity lies with state agencies at national, provincial and local levels of government, forming part of a wider responsibility for the environment and the sustainable use of natural resources. Constitutional and national laws require these environmental issues to be dealt with in cooperative, participatory, transparent and integrated ways.

The MBCP[9] is the first spatial biodiversity plan for Mpumalanga that is based on scientifically determined and quantified biodiversity objectives. The purpose of the MBCP is to contribute to sustainable development in Mpumalanga.

The MBCP, maps the distribution of the Mpumalanga Province's known biodiversity into six (6) categories. These are ranked according to: i) ecological and biodiversity importance, and, ii) their contribution to meeting the quantitative targets set for each biodiversity feature.

The categories are:

a) Protected areas – already protected and managed for conservation;

b) Irreplaceable areas – no other options available to meet targets—protection crucial;

c) Highly Significant areas – protection needed, very limited choice for meeting targets;

d) Important and Necessary areas – protection needed, greater choice in meeting targets;

e) Ecological Corridors – mixed natural and transformed areas, identified for long term connectivity and biological movement;

f) Areas of Least Concern – natural areas with most choices, including for development; and

g) Areas with No Natural Habitat Remaining – transformed areas that do not contribute to meeting conservation targets.

The study area comprises three (3) of these categories (**Appendix K**), namely:

a) Important and Necessary;

b) Least Concern; and

c) No Natural Habitat Remaining.

Areas included in the ‗*Important and Necessary*' category represent significantly important areas of natural vegetation that play an important role in meeting biodiversity targets. This category comprises approximately 9.5% of the Mpumalanga Province.

[9] ***Lötter, M.C. & Ferrar, A.A. 2006****. Mpumalanga Biodiversity Conservation Plan.*

Biodiversity assets in landscapes categorized as *'Least Concern'* contributes to natural ecosystem functioning, ensuring the maintenance of viable species populations and providing essential ecological and environmental goods and services across the landscape. This category comprises approximately 25.5% of the Mpumalanga Province. Although these areas contribute the least to the achievement of biodiversity targets, they have significant environmental, aesthetic and social values and should not be viewed as wastelands or carte blanche development zones.

Areas of *'No Natural Habitat Remaining'* comprise approximately 35.8% of the Province. This category has already lost most of its biodiversity and ecological functioning.

4.1.12.1 Development Restrictions in Terms of the MBCP

The proposed development relates to 'Urban and Industrial Land Uses' (Land Use Types 14 – Underground Mining[10]) and is included in the category with other development types, such as Surface Mining, Urban & Business Development, Major Development Projects, Linear Engineering Structures and Water Projects & Transfers.

These six (6) land uses cause the greatest environmental impact and are almost completely destructive of natural vegetation and natural biodiversity. Where biodiversity persists, it is artificially maintained, generally supporting only opportunistic assemblages of plants and animals. Ecosystem processes are completely disrupted, heavily impacted or artificially maintained at high cost. These land uses not only produce the highest local impacts but also dominate the dispersed and cumulative impacts. They are the most destructive and wide-ranging, often spreading hundreds of kilometres from their source, especially along river systems. These land-use types also require special provision in land-use planning, impact assessment and mitigation.

Classification in terms of Underground Mining Restrictions place most of the study area within the *'Permitted'* category with selected portions within the *'Restricted'* category. Specialist studies are therefore required to show that the proposed development will not add to existing cumulative impacts, regional degradation and habitat transformation and the loss of biodiversity on a local or regional scale.

4.2 Social Environment

4.2.1 Social

As mentioned in **Section 4.1.1**, the study area falls within the Pixley ka Seme Local Municipality (PKSLM). According to the Spatial Development Framework (SDF)[11] of the PKSLM, the current spatial pattern within the municipal area can be divided into seven (7) broad categories of land use, namely, urban land use, rural land use, mines and quarries, conservation areas, agriculture, tourism areas, and the transport network.

- **Urban land use**: The towns of Volksrust and Vukuzakhe are classified as major urban areas whereas Wakkerstroom, Daggakraal and Amersfoort are regarded as minor urban areas. An area such as Perdekop is regarded as a declining urban area.
- **Rural land use**: Agricultural activities seem to be dominating rural land use in the area, but most of these activities are regarded as subsistence farming.
- **Mines and quarries**: Operational mines are scattered throughout the PKSLM and include sand, dolerite and coal mining. Areas of coal mining are often also associated with energy generation activities.

[10] *Includes all underground mineral extraction and the surrounding „footprint" of related development, which may include small areas for residential and industrial uses. It includes all waste dumps, settlement ponds and disposal sites both above and below ground.*

[11] ***Pixley ka Seme Local Municipality, 2010.*** *Pixley ka Seme Local Municipality SDF. Available at URL http://pixleykaseme.local.gov.za.*

- **Conservation areas**: The PKSLM is home to a number of important conservation and biodiversity areas, but it would appear if these areas are mostly confined to the southern parts of the municipal area, notably around Wakkerstroom. In addition to the conservation areas, the SDF also states that there are a number of natural heritage sites located around Wakkerstroom and Warburton.
- **Agriculture**: The SDF describes the majority of land within the PKSLM as ―unimproved grassland" that is mostly used for stock grazing. Other land within the PKSLM is described as cultivated dry land used for crop cultivation (mostly maize).
- **Tourism**: The PKSLM falls within the Grass and Wetlands Tourism Region, which forms, what is called, a ―birding paradise".
- **Transportation network**: The national road N11 traverses the municipal area and serves as an important north-south transportation link. In addition, several provincial roads also traverse the local area, including the R23, and portions of the R543. Apart from the road network, two railway lines pass through the PSLM, one being the main Johannesburg-Durban rail connection, the other a north-south rail passing through the towns of Amersfoort, Wakkerstroom and Volksrust.

Amersfoort is classified as a small urban centre. The town was initially established as a result of the coal mining in the area and has since, to a large extent, become dependent on the Majuba Power Station.

Approximately 12.8 km to the south-east of Amersfoort lies the town of Daggakraal, which is considered a very large urban settlement. It is believed that up to a third of the total population of the PKSLM resides in Daggakraal. Furthermore, Daggakraal (and most probably neighbouring Vlakplaats) is expanding at a rapid rate which is evident in the fact that the population increased from approximately 6,500 in 2001 to an estimated 38,000 people in 2009.

Even though the town has a range of social services, there is still a dire need for a range of diversified services to address the needs of Daggakraal's residents, including physical upgrades such as sanitation services, water reticulation and waste removal. The town is economically unsustainable as it has a very limited economic base which shows little to no growth during the past years – probably owing to the fact that the area is very inaccessible.

4.2.2 Air Quality

4.2.2.1 Identified Sensitive Receptors

A sensitive receptor for the purposes of the current investigation can be defined as a person or place where involuntary exposure to pollutants released by the proposed plant, can be expected to take place. For the purposes of this study, areas of development are identified as sensitive receptors.

Those receptors identified during the current study are listed as follows:

- Approximately 8 km north-east is the Amersfoort town;
- Approximately 6 km west are the Vlakplaats and Daggakraal communities; and
- Adjacent to surrounding livestock farms and associated farm houses.

4.2.2.2 Sources of Air Pollution

The following sources of air pollution have been identified in the study area:

- Stack, vent and fugitive emissions from the existing Majuba Power Station operations;
- Flaring and fugitive emissions at the UCG pilot plant operations;
- Agricultural activities on the surrounding farms;
- Vehicle entrained dust and exhaust emissions;
- Domestic fuel burning; and
- Veld fires.

4.2.2.3 Standards and Guidelines

Air quality Guidelines and Standards are generally only given for criteria pollutants. No such thresholds exist for the less common, toxic pollutants. In the absence of such guidance reference needs to be made to other health impact criteria such as effect screening levels (ESLs), reference exposure levels (RELs), inhalation reference concentrations (RfC) and unit cancer risk factors. The following information summarises the ambient air quality Standards available locally for various criteria pollutants under investigation during the current study.

Table 24: Air quality standards

Substance	10-minute maximum	1-hour maximum	8-hour maximum	24-hour maximum	Annual average
Inhalable Particulate Matter (PM10)				120 µg/m³ 75 µg/m³ (3)	50 µg/m³ 40 µg/m³ (3)
Sulphur Dioxide (SO_2) (1)	500 µg/m³	350 µg/m³		125 µg/m³	50 µg/m³
Nitrogen Dioxide (NO_2) (1)		200 µg/m³			40 µg/m³
Carbon Monoxide (CO) (1)		30 mg/m³	10 mg/m³		
Benzene (C_6H_6)					10 µg/m³ 5 µg/m³ (3)
Hydrogen Sulphide (H_2S) (2)		7 µg/m³ (30 mins)			
Ammonia (NH_3) (4)					100 µg/m³

Note:
(1) South African Standard
(2) WHO Guideline
(3) To come into effect 2015
(4) US EPA Guideline

- ***Particulate Matter***

Particulate matter (PM) is the collective name for the fine solid or liquid particles added to the atmosphere by processes at the earth's surfaces. PM includes dust, smoke, soot, pollen and soil particles. PM has been linked to a range of serious respiratory and cardiovascular health problems. The key effects associated with exposure to ambient particulate matter include: premature mortality, aggravation of respiratory symptoms, chronic bronchitis, decrease lung infection, and increased risk of myocardial infarction[12].

[12] ***USEPA, 1996.*** *Air Quality Criteria for Particulate Matter.*

- ***Sulphur dioxide***

Sulphur dioxide (SO_2) is the colourless gas which smells like burnt matches. It can also be oxidized to sulphur trioxide, which in the presence of water vapour is readily transformed to sulphuric acid mist. Sulphur dioxide can be oxidized to form acid aerosols and is also a precursor to sulphates which are one of the main components of respirable particles in the atmosphere. Health effects caused by exposure to high levels of sulphur dioxide include breathing problems, respiratory illness, changes in the lung's defences, and worsening respiratory and cardiovascular disease. People with asthma or chronic lung or heart disease are most sensitive to sulphur dioxide. Sulphur dioxide and nitrogen oxides are the main precursors of acid rains.

- ***Nitrogen dioxide***

Nitrogen dioxide (NO_2) has an irritating odour which transforms in the air to form gaseous nitric acid and toxic organic nitrates. Nitrogen dioxide plays a major role in atmospheric reactions that produces smog. Nitrogen dioxides can be a significant emission released from motor vehicles especially from poorly maintained vehicles and from diesel vehicles. Nitrogen dioxides can irritate lungs and lower resistance to respiratory infection and increases sensitivity to people with asthma and bronchitis. It can also damage trees and crops if it is transformed into nitric acid.

- ***Carbon monoxide***

Carbon monoxide (CO) is an odourless, colourless and toxic gas. At lower levels of exposure, CO causes mild effects that are often mistaken for the flu. These symptoms include headaches, dizziness, disorientation, nausea and fatigue. The effects of CO exposure can vary greatly from person to person depending on age, overall health and the concentration and length of exposure.

- ***Benzene***

Benzene is an aromatic hydrocarbon that is produced by the burning of natural products. It is a component of products derived from coal and petroleum and is found in gasoline and other fuels. Research has shown benzene to be a carcinogen (cancer-causing). With exposures from less than five years to more than 30 years, individuals have developed, and died from, leukaemia. Long-term exposure may affect bone marrow and blood production. Short-term exposure to high levels of benzene can cause drowsiness, dizziness, unconsciousness, and death.

- ***Hydrogen sulphide***

Hydrogen sulphide (H_2S) is a colourless gas, soluble in various liquids including water and alcohol. It can be formed under conditions of deficient oxygen, in the presence of organic material and sulphate. In industry, hydrogen sulphide can be formed whenever elemental sulphur or sulphur-containing compounds come into contact with organic materials at high temperatures. Hydrogen sulphide is formed, for instance, during coke production, in viscose rayon production, in waste water treatment plants, in wood pulp production using the sulphate method, in sulphur extraction processes, in oil refining and in the tanning industry. The lowest-adverse-effect level of hydrogen sulphide is 15 mg/m^3, when eye irritation is caused. In view of the steep rise in the dose-effect curve implied by reports of serious eye damage at 70 mg/m^3, a relatively high protection (safety) factor of 100 is recommended, leading to a guideline value of 0.15 mg/m^3 with an averaging time of 24 hours. A single report of changes in haem synthesis at a hydrogen sulphide concentration of 1.5 mg/m^3 should be borne in mind. In order to avoid substantial complaints about odour annoyance among the exposed population, hydrogen

sulphide concentrations should not be allowed to exceed 7 µg/m^3, with a 30-minute averaging period. When setting concentration limits in ambient air, it should be remembered that hydrogen sulphide is emitted from natural sources in many places.

- ***Ammonia***

Ammonia (NH_3) is released to the atmosphere by natural processes such as the decay of organic matter and animal excreta, or by volcanic eruptions. It can also be released to the atmosphere by anthropogenic activities such as fertilizer use; spillage or leakage from storage or production facilities; or by loss from waste water effluents. Releases to water are usually due to effluent from sewage treatment plants or industrial processes, or run-off from fertilized fields or livestock areas. Soils usually obtain ammonia from natural or synthetic fertilizer application, animal excreta, decaying organic matter, or natural fixation from the atmosphere. In the atmosphere, ammonia can react with acidic substances in the air to produce ammonium aerosols, which can undergo dry or wet deposition.

The most important injurious effects of ammonia on humans are due to its irritative and corrosive properties. Exposures to ammonia as a gas cause chemical burns of the respiratory tract, skin, and eyes. Airway blockage and respiratory insufficiency may be lethal outcomes of exposure to anhydrous ammonia vapours or concentrated aerosols. Survival of the initial insult may be compromised by infections, scarring, and other complications that may develop days or weeks following inhalation or ingestion. Effects that have been observed in humans exposed to ammonia as a gas and ammonium salt aerosols have also been observed in animals. Hepatic and renal effects have also been reported in animals and humans; however, ammonia does not appear to be a primary liver or kidney toxicant[13].

Ammonia is an upper respiratory irritant in humans. Exposures to levels exceeding 50 ppm result in immediate irritation to the nose and throat; however, tolerance appears to develop with repeated exposure. Exposure to an air concentration of 250 ppm is bearable for most persons for 30 – 60 minutes. Acute exposure to higher levels (500 ppm) have been shown to increase respiratory minute volume. Accidental exposures to concentrated aerosols of ammonium salts or high concentrations of ammonia gas have resulted in nasopharyngeal and tracheal burns, airway obstruction and respiratory distress, and bronchiolar and alveolar edema. Chronic occupational exposure to low levels of airborne ammonia (<25 ppm) had little effect on pulmonary function or odour sensitivity in workers at some factories, but studies of farmers exposed to ammonia and other pollutants in livestock buildings indicated an association between exposure to pollutants, including ammonia, and an increase in respiratory symptoms (such as bronchial reactivity/hyper responsiveness, inflammation, cough, wheezing, or shortness of breath) and/or a decrease in lung function parameters. The contribution of ammonia to these respiratory symptoms is unclear[14].

4.2.3 Micro-economic Status Quo

The current regional economic environment seems to be dominated by agriculture, and power generation, with towns in the area providing services and products to these industries and local residents providing labour to the industries or running related businesses. This is supported by information contained in the Pixley ka Seme Local

[13] ***USEPA, 2002.*** *Review of emission factors and methodologies to estimate ammonia emissions from animal waste handling.*
[14] Ibid. *Footnote 13.*

Municipality IDP[15] which indicated that agriculture and electricity provision both represented significant sectors in the local economy together with trade and manufacturing.

4.2.4 Regional Economic Indicators and Trends

4.2.4.1 Industry Profile

At a district level the economy is dominated by manufacturing and mining, indicating a strong focus on industrial activity in general. It is likely that other industries in the Gert Sibande District Municipality (GSDM) area are likely focused on delivering supporting services to these sectors. Details can be found in **Figure 20** below:

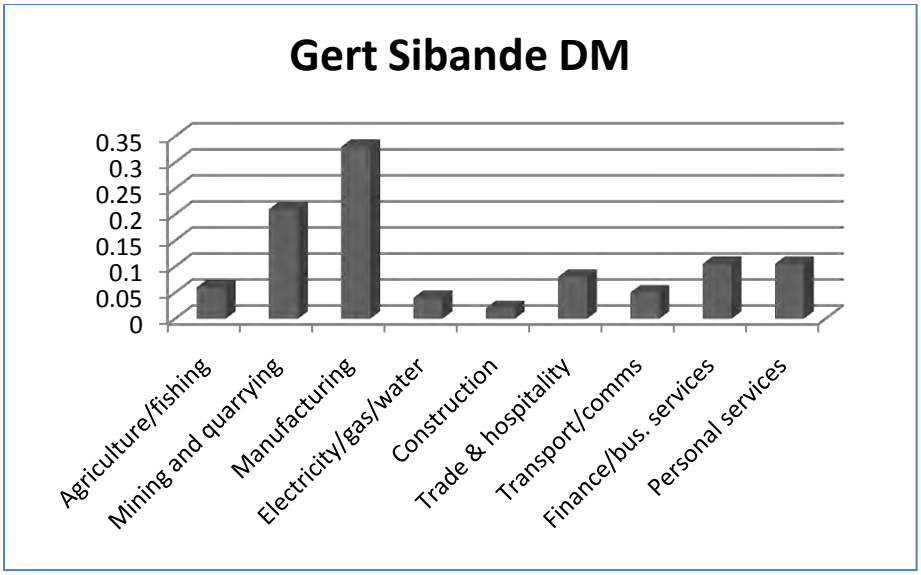


Figure 20: Industry sector contribution Regional GDP for the GSDM[16]

The information provided in the Gert Sibande Spatial Development Framework (SDF) indicates that majority of economic activity is located within the central and western areas of the District, towards Gauteng and the southern economic activity areas of the Nkangala District. Significantly, the town of Secunda dominates Gross Value Added (GVA) in Mpumalanga at 21.3%. All of the remaining areas making the largest contributions to the District GVA, except Piet Retief, are found within the central and western extents of the District.

The PKSLM area (comprising the Amersfoort and Volksrust centres) is an important agricultural hub, and activities in other industries probably support and serve the agricultural industry and those working in them.

Although tourism is seen as an important growth industry in the province and in the GSDM area, the PKSLM area does not seem to be particularly rich in features or infrastructure that could be utilised for tourism potential and tourism is unlikely to be seen as a viable alternative to agriculture.

4.2.4.2 Education Profile

The education profile in rural areas such as PKSLM remained similar from 2001 to 2007 with a minority of residents having matric and post-matric qualifications. The summary of the education profile is given in **Table 25**.

The data includes the total population in the PKSLM.

[15] ***Pixley ka Seme Local Municipality, 2009 – 2012.*** *Pixley ka Seme Local Municipality IDP. Available at URL http://pixleykaseme.local.gov.za.*
[16] *Gert Sibande District Municipality (2010).*

Table 25: Education profile of the PKSLM

Education	2007	2001
No schooling	24.0%	35.3%
Some Primary	30.1%	19.4%
Complete Primary	5.2%	5.6%
Some secondary	25.2%	22.4%
Grade 12	9.3%	12.5%
Higher	6.2%	4.8%

As can be seen from the above, there has been a slight increase (1.4%) in the number of persons with a higher education and a 3.2% decrease in matriculants.

A significantly larger portion now has some primary schooling compared to the 2001 census, however, this may not result in a significant increase in the ability to fill jobs and derive income from skilled employment sectors. As a result employment will often require training and skills development in order to exploit the full potential of workers.

4.2.4.3 Local Employment

The number of employed and unemployed persons have increased from 2001 to 2007 indicating that a larger number of individuals are now economically active and are seeking employment. However, the employment situation remains largely unchanged with employment in the PKSLM being relatively low when compared to district, regional and national employment.

As recent economic growth has resulted in limited job creation, unemployment remains high especially in rural areas such as the project location. This increases the importance and potential positive local impact of large-scale infrastructure projects.

Table 26 below summarises the current employment statistics:

Table 26: Overview of employment

Labour Status	South Africa*	Mpumalanga Province	GSDM	PKSLM	
	2001	2007		2001	2007
Employed**	33.7%	40.1%	43.4%	25.1%	28.5%
Unemployed	24.0%	20.0%	21.6%	26.2%	31.9%
Not economically active	42.3%	39.9%	35.1%	48.0%	40.0%
Employment rate***	58.4%	66.7%	66.8%	49.3%	47.1%

Source: Community Survey 2007 and Census 2001
** Census 2001 data*
*** This is the percentage employed/unemployed of the entire working age population and should not be read as the unemployment rate, i.e. the not economically active population is included in this segment.*
**** In order to reflect a more accurate employment rate, the not economically active population has been excluded from this segment*

Table 27: Industry employment in PKSLM

Industry	PKSLM (2001)
Agriculture	20.5%
Mining	0.4%
Manufacturing	8.6%
Electricity	5.1%
Construction	4.5%
Trade	13.8%
Transport	2.6%
Financial	4.1%
Services	17.6%
Private households	0.5%
Other	17.9%
Undetermined	4.4%

Currently agriculture, services and trade are the biggest employers in the area, with some manufacturing employment taking place. The percentages given in **Table 27** provide further supporting evidence of the continued local dominance of the agricultural industry from 2001 to the present day. However, in the future the possibility of further industrial development may contribute to declining local employment in the agricultural industry if land-use patterns change.

4.2.4.4 Local Household and Personal Income

A regional and provincial income analysis is indicated in **Table 28** below:

Table 28: Monthly personal income in PKSLM[17]

Income	GSDM (2007)	PKSLM (2007)
No Income	51.0%	51.1%
R1 – R1,600	27.9%	39.0%
R1,601 – R25,600	20.2%	9.4%
R25,601+	0.9%	0.2%

At a municipal level more than half (51.1%) of the total population between 15 and 65 registered no income in 2007 followed by just over a third (39.0%) of those who earn an income of R1,600 or less per month. Figures for persons with no income are relatively consistent with district level results, however, income earners in PKSLM are likely to be poorer if the figures for those earning an income (i.e. earning above R1 a month) are considered.

The category percentages thus indicate low local income access, and local residents will benefit substantially from any development that is able to create income for more individuals. As income is related to skills and employment any recommendation applicable to education and employment will influence income.

4.2.4.5 Local Economic Feature of Importance

Interviews conducted with selected landowners indicate that it is likely that portions of the surrounding farms are being used for agriculture as the main activity.

[17] *Source: Community Survey 2007 and Census 2001. Note: Data is for persons from 15 to 65 years of age.*

Table 29: Examples of current land use activities in the surrounding farms

Farming Operation	Size	Activities
Koppieskraal Portion 9	327 ha	Agricultural, with 70% used for cattle and 30% cultivated agriculture. Carrying capacity of grassland is 3 ha per head of cattle. Maize is main crop but soya and cattle fodder also cultivated.
Palmietspruit Portion 3, Strydkraal Portion 8	1,230 ha	Land currently being rented to a tenant who is using it for cultivation agriculture. Regular crops are maize, soya and sunflower.
Strydkraal Portions 1, 3 and 6	1,185 ha	Agricultural, with 50% used for cattle and 50% cultivated agriculture. Carrying capacity of grassland is 3 ha per head of cattle. Currently farming 140 cattle and 1000 sheep. Maize and soya are both cultivated.
Tweedepoort Portions 2 and 4	684 ha	Agricultural, with 70% used for cattle and 30% cultivated agriculture. Carrying capacity of grassland is 2.5 ha per head of cattle. Maize is main crop but cattle fodder also cultivated.
Weiland Portion 8	400 ha	Agricultural, with 55% used for cattle and 45% for cultivated agriculture. Carrying capacity of grassland is 3 ha per head of cattle and 6 ha per sheep. Soya is main crop but cattle fodder also cultivated on 12 ha.
Bergvliet Portions 3,4,7,16-18	1,146 ha	Agricultural, with 100% used for cattle. Carrying capacity of grassland is between 2.5 ha and 3.5 ha per head of cattle depending on location. During social studies conducted in 2008 the owner indicated that the farming operation is not profitable, situation has improved by 2010.

4.2.5 Heritage – Larger Region

4.2.5.1 Rural Landscape

The rural landscape has always been sparsely populated and it was only during the last couple of hundred years that people, through the application of specific economic strategies, succeeded to occupy a section of the region for any length of time.

Archaeological sites in this area predominantly date to the Late Iron Age, although some sites dating to the Stone Age are also found in the larger region. Human occupation of the larger geographical region took place since Early Stone Age (ESA) times. This is evidenced by the scattered stone tools found in a secondary context (open surface material), where they have been exposed in gravel terraces by rivers and streams. Normally this material is viewed to have a low significance and the localities where they are found are referred to as ~~"fi~~nd spots" rather than sites. As this region was probably too cold and it does not have many rock shelters, occupation during Stone Age times remained low, resulting in very few sites dating to this period occurring in the region.

Iron Age people started to settle in southern Africa c. AD 300, with one of the oldest known sites at Silver Leaves, south east of Tzaneen dating to AD 270. However, Iron Age occupation of the eastern Highveld area (including the study area) did not start much before the 1500s. Some sites dating to the Late Iron Age is known to exist to the north west of the study area. As this was a period signified by high stress levels, people tended to settle in towns, usually located on hill tops for protection. The villages were laid out in a complex manner and different areas were demarcated by stone walled enclosures.

4.2.5.2 Farmsteads

Farmsteads are complex features in the landscape, being made up of different yet interconnected elements. Typically these consist of a main house, gardens, outbuildings, sheds and barns, with some distance from that

labourer housing and various cemeteries. In addition, roads and tracks, stock pens and windmills complete the setup.

By the early 19th century white settlers took up farms. An investigation of the Title Deeds of most of the farms under consideration indicated that they were surveyed as early as the 1860s, implying that they would have been occupied by colonists since then.

Many farmsteads and even houses in Amersfoort were destroyed during the Anglo Boer War. As a result most structures date to the period after that. The architecture of these farmsteads can be described as eclectic as they were built and added to as required over a period of time. In some cases outbuildings would be in the same style as the main house, if they date to the same period. However, they tend to vary considerably in style and materials used.

4.2.5.3 Cemeteries

Apart from the formal cemeteries that occur in municipal areas (towns or villages), a number of these, some quite informal, i.e. without fencing, occur sporadically all over. Many also seem to have been forgotten, making it very difficult to trace the descendants in a case where the graves are to be relocated. Most of these cemeteries, irrespective of the fact that they are for landowner or farm labourers (with a few exceptions where they were integrated), are family orientated. They are therefore serve as important ‗documents' linking people directly by name to the land.

4.2.5.4 Infrastructure and Industrial Heritage

In many cases, this aspect of heritage is left out of surveys, largely due to the fact that it is taken for granted. However, the land and its resources could not be accessed and exploited without the development of features such as roads, bridges, railway lines, electricity lines and telephone lines.

4.2.5.5 Urban landscape

The urban landscape in the region includes a number of small towns, of which Amersfoort is the closest to the study area. The study area *per sé* does not contain any section that can be classified as an urban environment.

4.2.5.6 Palaeontology

By their nature coals are plant-rich. Good quality coals do not preserve the anatomy of the original plant matter, but the shales between the sequences do. Here it is possible to find well preserved *Glossopteris* leaves, roots and inflorescences, lycopod and sphenophyte stems, ferns, cordaitaleans and early gymnosperms. A Phase 1 assessment has shown that no vertebrae fossils are likely to be found but fossil plants are likely to be encountered. This type of flora is common and of little scientific interest.

It is therefore recommended that a responsible person (geologist, environmental officer, or other) regularly monitors the excavations, removes and collects fossil material that is found. The fossils should then be given to an institute that is recognised by SAHRA as a repository for fossils.

4.2.5.7 Noise

The *noise climate* (ambient noise condition) in the Amersfoort area is quiet and is representative of a rural (farming) noise district (SANS 10103).

There are a number of major noise sources in the area namely the existing Majuba Power Station, the traffic on the main roads, coal trucks transporting coal to Majuba Power Station and the coal supply railway line to the power station.

The noise sensitive sites / areas are Amersfoort town (approximately 12 km from the Majuba Power Station) and various farmhouses and farm labourer residences in the surrounding area (on farms Palmietspruit; Strydkraal; Tweedepoort, Koppieskraal, Rietfontein; Weiland and Bergvliet).

4.2.5.8 Traffic

There are a number of major roads and secondary roads servicing the study area.

These include:

a) National Road N11, which links Amersfoort to Volksrust, is aligned in a north-south direction through the eastern sector of the study area.

b) Road P48/2 (Route R35), which links Amersfoort to Morgenzon, is aligned in an east-west direction through the north-eastern sector of the study area.

c) Road P97/1 which links Amersfoort to Perdekop, is aligned in a north-east to south-west direction through the western sector of the study area. It passes 4 kilometres to the north-west of the Majuba Power Station.

d) Road D2514, which links from Road P97/1 to National Road N11, is aligned in a north-west to south-east direction through the central portion of the study area. It is the main access road to Majuba Power Station.

e) Road D284, which links from Road D2514 to National Road N11, is aligned in a south-west to north-east direction through the central portion of the study area. It is the main access road to Majuba Colliery (no longer in operation).

4.2.5.9 Visual

4.2.5.10 Landscape Structural Components

The study area is located in a rural part of south-eastern Mpumalanga, between the nearby town of Amersfoort to the north and the regional centre of Volksrust to the south. The study area‘s visual environment is based on a number of physical factors, including the topography, vegetation, land-use, and presence of the built environment.

In a wider context, the south-eastern Mpumalanga Highveld is largely flat to undulating, forming part of the high-lying interior plateau (Highveld) that occurs in the north-eastern interior of South Africa. The Great Escarpment that forms the edge of the interior plateau is located to the south of the study area in the vicinity of the town of Volksrust, with prominent hills such as the historical Amajuba Mountain forming part of the escarpment that separates the high-lying Highveld plateau from the lower-lying areas with KwaZulu-Natal around Newcastle.

The flat to undulating topography is largely due to the underlying geology – the south-eastern Highveld is largely underlain by the Karoo Supergroup, comprising largely of sedimentary rocks such as sandstone and shale. The presence of this geology and the way in which it weathers gives rise to largely flat to gently undulating topography. However another geological factor has played an important part in the geological evolution of the landscape in the study area, i.e. the large-scale intrusion of the sedimentary sequences by igneous (volcanic) rock in the form of dolerite. Large parts of the study area are comprised of this dolerite intrusion. Dolerite is a harder rock less prone to weathering, and thus it forms the higher-lying prominent parts of the landscape such

as ridges and interfluves, e.g. the Graskop koppie located to the south of the study area close to the N11 highway.

As it occurs within this interior plateau, the topography of the study area is gently undulating, with streams and wetlands draining shallow valley bottoms. The northern parts of the study area (closer to the town of Amersfoort) that are underlain by dolerite are generally a little more incised than the flatter areas underlain by sedimentary geology in the south (i.e. around the Majuba Power Station), although the revised development site is not as deeply incised as the valley of the Palmietspruit located just to the west.

Photograph 11: Very gently sloping terrain in an area of sedimentary geology on the Rietfontein site

The climate and underlying soils have determined the nature of the natural vegetation in the study area. The nature of the climate – i.e. summer rainfall with cold winters characterised by much frost occurrence, and the presence of fire as driving factor entail that the south-eastern Highveld is naturally characterised by grassland vegetation. Natural woody vegetation typically only occurs on ridges where the presence of outcropping rock provides the woody vegetation enough protection from fires to be able to survive.

The study area is thus characterised by short, open grassland which gives rise to wide vistas over the gently undulating terrain. Due to the nature of the land-use as described below, much of this natural grassland still exists over the wider study area. In small areas, particularly around farmsteads or in small woodlots, groves of exotic trees (in particular eucalyptus) have historically been established. The widespread presence of vertic clay soils as described below has precluded the wider establishment of trees in the study area.

The predominant land-use and economic activity in the wider area is livestock (cattle) farming. In much of the study area the nature of the soils (strongly vertic clay soils that are characterised by strong swelling and shrinking properties) precludes the growth of crops, but in small areas crops are grown. As such most of the area in which livestock rearing occurs is comprised of natural grassland.

There is a strong industrial component to the study area, with the Majuba Power Station located on the boundary of the revised development site. The power station is comprised of a number of massive structures including three cooling towers, the power station building itself and two very tall stacks. In the power station complex there are other buildings / infrastructure such as raised conveyors belts and a large ash dump. Due to its massive

bulk, the Majuba Power Station (**Photograph 12**) is visually very prominent across the study area, with most localities within the study area and its immediate surrounds being able to see the power station. The power station thus dominates views within the study area, especially within a 5 km radius.

There is a significant amount of associated infrastructure present, in particular a number of high voltage power lines that link the power station with the wider electricity grid. A number of such power lines radiate out from the power station to the east and to the west. Coal is supplied to the power station by truck traffic, and there is an almost constant supply of coal trucks travelling to and from the power station along the power station access road from the R35 (Morgenzon-Amersfoort Road), and (to a lesser degree) along the Perdekop Road to the west.

Photograph 12: Majuba Power Station

There are other aspects of the built environment within the study area, including the disused coal mine at Bergvliet west of the N11 (comprising of headgear and a number of buildings) as well as the concentration of structures within the small town of Amersfoort to the north-east, and within the settlement of Daggakraal to the east. Rural farmsteads are dotted across the study area, although many of these are disused / abandoned.

There is an existing gas field on the Roodekopjes property although this is not typically visible as it is located on Eskom-owned property (Roodekopjes) onto which access is largely limited to the general public. A number of other aspects of typical rural infrastructure are located in the study area, such as smaller power lines and phone lines, windmills and communication towers on certain higher-lying areas.

5 PUBLIC PARTICIPATION

5.1 Aims of the Public Participation Process

The primary aims of the public participation process are:

- To inform interested and affected parties (I&APs) and key stakeholders of the proposed application and environmental studies;

- To initiate meaningful and timeous participation of I&APs;
- To identify issues and concerns of key stakeholders and I&APs with regards to the application for the development (i.e. focus on important issues);
- To promote transparency and an understanding of the project and its potential environmental (social and biophysical) impacts (both positive and negative);
- To provide information used for decision-making;
- To provide a structure for liaison and communication with I&APs and key stakeholders;
- To assist in identifying potential environmental (social and biophysical) impacts associated with the proposed development;
- To ensure inclusivity (the needs, interests and values of I&APs must be considered in the decision-making process);
- To focus on issues relevant to the project, and issues considered important by I&APs and key stakeholders; and
- To provide responses to I&AP queries.

5.1.1 Consultant with Competent Authorities

The competent authorities issuing decisions regarding the project as well as consultation to date are presented in below. Linked information is provided in **Appendix B**.

Table 30: Competent authorities and other relevant authorities associated with the project

Authority	Role	License / Approval	Consultation to date
Department of Environmental Affairs (DEA)	Competent Authority for integrated Environmental Authorisation process	Waste Management License and Environmental Authorisation	• Pre-application meeting • S24G application submission
Department of Mineral Resources (DMR) – Mpumalanga Region	Competent Authority for mining right application process	Mining Right	• Prospecting licences
Department of Water Affairs (DWA)	Competent Authority for Integrated Water Use License process	Integrated Water Use License	• Pre-directive issued on 22 November 2012 • IWULA submitted on 31 January 2013 • Follow-up meeting with DWA on 06 February 2013
Mpumalanga Department of Economic Development, Environment and Tourism (MDEDET)	Commenting Authority for integrated Environmental Authorisation process		• Notification of parallel S24G process
SAHRA – Mpumalanga Region	Heritage Authority	Approval indicating that the application fulfils the requirements of the relevant heritage resources authority as described in Chapter II, Section 38(8) of the NHRA, Act 25 of 1999	• Letter received on 21 November 2012 • Interim comment received on 03 December 2012 • Interim comment received on 05 February 2013 • Notification of parallel S24G process

5.1.2 Consultation with other Relevant Authorities and Key Stakeholders

Consultation with other relevant authorities and key stakeholders was undertaken via telephone calls, written correspondence, and where appropriate, personal visits to specifically identified I&APs, in order to actively engage these stakeholders from the outset and to provide background information about the proposed project (refer to **Appendix E** for proof of notification).

The following authorities and key stakeholders have been consulted with to date as part of the parallel EIA process. As the same I&AP database is being used for the S24G process, by default the following stakeholders will be contacted in connection with the application process at hand. Note that consultation will in some cases take the form of focus group meetings with the relevant authority (e.g. Pixley ka Seme LM).

- National and Provincial Government:
  - Department of Agriculture, Forestry and Fisheries;
  - Department of Labour;
  - Department of Public Enterprises;
  - Department of Trade and Industry;
  - Mpumalanga Department of Agriculture, Rural Development and Land Administration;
  - Mpumalanga Department of Health;
  - Mpumalanga Public Works, Roads and Transport;
  - Mpumalanga Department of Human Settlements; and
  - Mpumalanga Department of Social Development;
- Pixley ka Seme Local Municipality and Gert Sibande District Municipality;
- Ward councillors;
- South African Heritage Resource Association (SAHRA) – Mpumalanga office;
- Mpumalanga Tourism and Parks Agency;
- Neighbouring property owners/landowners;
- Farmers Associations; and
- Environmental interest groups and NGOs.

5.1.3 Advertising

Advertisements on the availability of the EIAR for public comment and public meeting will be placed in the Volksrust Recorder and City Press newspapers.

5.1.4 Identification of Interested and Affected Parties

I&APs and key stakeholders were identified during the parallel EIA process of the wider UCG project. The identification of I&APs and key stakeholders was revisited during this process and any I&APs that wish to now register will be given the right to register for both the S24G and ongoing EIA process. This is indicative of the fact

that the public participation process is a continuous process that runs throughout the duration of any environmental investigation (or combination of such investigations).

5.1.5 I&AP Database

All I&AP information (including contact details), together with dates and details of consultations and a record of all issues raised is recorded within a comprehensive database of I&APs (refer to **Appendix E**). This database has been updated on an on-going basis throughout the project, and will act as a record of the communication / involvement process.

5.1.6 Issues Trail

All issues, comments and concerns raised during the public participation process to date will be compiled into an Issues Trail that will be attached to the final EIAR.

5.1.7 Public Review of the Draft Environmental Impact Assessment Report

The draft document at hand, the EIAR, will be made available for public review for a 40 day review period. Hard copies of the report will also be made available for review at the following public places:

- Volksrust Public Library, Cnr Joubert & Laingsnek Street, Volksrust;
- Amersfoort Public Library, Cnr Plein & Bree Street, Amersfoort;
- UCG Mine Site Offices, Majuba Colliery, Bergvliet, Amersfoort;
- Office of Royal HaskoningDHV, 78 Kalkoen Street, Monument Park, Pretoria; and
- Royal HaskoningDHV website (http://www.rhdhv.co.za/pages/services/environmental/current-projects.php).

5.1.8 Public and Authority Review of the Draft Environmental Impact Assessment Report

The draft S24G-specific EIAR will be made available at public places for public review and comment. The draft EIAR will also be submitted to the DEA, DMR, DWA, and, MDEDET simultaneously. A 40 calendar day period will be allowed for this review process.

An advertisement indicating the availability of this report for public scrutiny will be placed in the local newspaper.

I&APs registered on the project database will be notified of the availability of this report by correspondence (i.e. letters, emails, flyers, radio announcement). All I&AP notifications are attached in **Appendix E**.

5.1.9 Public and Authority Review of the Final Environmental Impact Assessment Report

In order to give effect to regulation 56(2) of the EIA Regulations (2010), before submitting the final EIAR to the DEA, the EAP must give registered I&APs access to, an opportunity to comment on the report in writing within 21 days.

5.1.10 Authority Review and Decision-making

After the public review period, all relevant comments received from the public will be considered and included into the final EIAR. This final document will be submitted to DEA for final review and decision-making.

5.1.11 Environmental Authorisation

On receipt of the environmental authorisation for the project, I&APs registered on the project database will be informed and its associated terms and conditions by correspondence.

6 SPECIALIST FINDINGS AND RECOMMENDATIONS

The findings and recommendations of the specialists and reports of specialised processes have been incorporated in this chapter.

The following studies have been undertaken as part of this and the parallel EIA processes (i.e. Pilot Plant Phase 1 and 2 investigations):

- Geology (**Appendix F**)
- Hydrogeology (**Appendix F**)
- Hydrology (**Appendix G**)
- Wetlands (**Appendix H**)
- Freshwater Ecology (**Appendix I**)
- Soils and Agricultural Potential (**Appendix J**)
- Biodiversity (**Appendix K**)
- Waste (**Appendix L**)
- Social (**Appendix M**)
- Air Quality (**Appendix N**)
- Heritage and Palaeontology (**Appendix O**)

6.1 Geology

Note that this section refers dominantly to future expansion of the UCG process based on outcomes of the Pilot Plant Phase 1 covered so far. It is provided for completeness although it does not have specific reference to Gasifier 1‘s (Pilot Plant Phase 1) future fate, as it indicates the fact that the phases form an ongoing research process with the results obtained informing the next steps taken.

6.1.1 Geological Studies

The following geological studies (conducted by Eskom personnel) are completed:

1. A Geological report of Gasifier 1 (Pilot Plant Phase 1) is in progress. This report is an overview of the geological characteristics of the G2 panel area, with the following objectives in mind:
    - Mineral Resource Calculation of the Gus coal seam in the G2 Panel Area.
    - An interpretation of the geological structure of the G2 Panel, Majuba UCG Gasifier One Area.

- Illustrate the general geological environment of the identified mining area and to highlight conditions to be considered for gasifier design and development.
- Summarised Gus seam coal quality results.
- Complete drilling, geological and wireline logging results and provision of a consolidated database.

2. Desktop study of opening-mode fractures in coal seams (coal cleat):

   The aim of this desktop study is to establish a method of capturing and mapping in-situ data with regards to fractures within the Gus coal seam. Geophysical / wireline logging techniques will be approached, together with orientated drill core. Confirmation pending on scheduled diamond core prospecting programme of 2013.

   Cleat orientation mapping is critical to determine the maximum principal compressive horizontal stress direction for UCG exploration and exploitation, which in turn controls the direction of maximum gas or water flow though coal beds.

3. Geophysical exploration methods to be trailed: Review:

   Numerous geophysical exploration methods are conducted at various mineral exploration projects. At Majuba, historical data from a Gravity Survey and an Aeromagnetic Survey in the Majuba area was conducted in the early 1990's. The shortcomings of these surveys were mainly due to the fact that the overlying dolerite sills served as a "shield / barrier". Dolerites were both magnetic and non-magnetic, if any dyke originated from an underlying sill, it could not be detected from the Aeromagnetic survey. The abovementioned methods are not suitable for detecting dykes (in seam) in the Majuba area.

   In seam seismics, cross-hole seismics, electric resistance tomography and seismic refraction methods are currently being investigated for feasibility.

4. Recommendations from previous geological studies to be implemented, where applicable, during future proposed prospecting (drill core availability):

   Numerous recommendations have been documented in various Geological reports of the Majuba area. The aim of this exercise is to implement the relevant recommendations, especially regarding sampling and recovery of drill core. Detailed descriptions of core, as well as dolerite sampling strategies should be looked at. Adoption of several recommendations regarding drilling, logging, sampling, reporting and communication is crucial. Raw coal analysis of all subordinate seams within the Coal Zone should also be considered.

5. Coal resource calculations:

   In order to establish a measured resource, a borehole spacing grid of 350 m, as per SAMREC code and SANS10320 is recommended. This would be applicable to identify potential target areas for erecting gasifiers with proven reserve status. At the current Gasifier 1 area, a measured resource have already been established.

6. Comparing coal quality results with wireline logs (Natural gamma, density):

   The viability to use density and gamma information to predict coal quality is currently being examined. This involves comparing coal quality analyses of cored samples of the Gus coal seam (a complete proximate and ultimate analyses of the entire Gus seam) and then comparing results with the geophysical signature on the wireline logs. This is an on-going study pending on core availability and wireline (density) information.

7. Prediction of dolerite activity:

   Upon completion of coal analyses, a Dry Ash Free Volatile Matter calculation should be conducted. This will confirm whether the seam (results) have been exposed to heat from the dolerite (establish the devolatilised nature of the coal seam, if present). Short comings from previous coal percussion drill cuttings results have been regarded as unreliable.

6.1.2 UCG Rock Mechanics Monitoring

A new Time Domain Reflectometry (TDR) system has been proposed at Gasifier 2 based on findings from Gasifier 1. Key learning points from the previous TDR installation were incorporated into the design of the new system.

6.1.2.1 Shortcomings of the previous monitoring system

A number of shortcomings have been identified in the previous monitoring system. The system has not yielded much data since it was installed in 2006. The main shortcomings of both the TDR and wire extensometer system were:

- The limited number of monitoring boreholes in relation to the unknown location, profile and extent of the gasification cavity.
- The location of the assigned boreholes in relation to the location of the cavity. The location was not in the direct path of the initial burn but rather to the side. Therefore, the predicted caving above the cavity would have been a pseudo-convex shape (Gothic arch) and any offset of the monitoring boreholes from the centre of the cavity would have negatively affected the effectiveness of the monitoring system.
- The depth of the boreholes – the boreholes terminated approximately 10 m above the coal seams, there were concerns of gas leakage through the holes. The physical location, extent or envisage size of the cavity could not be predicted with certainty at that stage of the project and therefore it was not known if this 10 m proximity above the seam would be adequate or not.

As a consequence of the location and depth, the extensometer system cannot detect current deformation and movement of the immediate strata above the cavity.

6.1.2.2 Tracking UCG Cavity Growth

Understanding the growth of the cavity is important from a Process and Rock Engineering point of view. The information obtained from a system of tracking UCG cavity growth can be used to determine the size and shape of the gasification chamber. A number of geophysical techniques that can be used to track the UCG cavity were investigated. A Microseismic Monitoring system was identified as the most suitable technique to track the UCG cavity growth. Eskom UCG has currently purchased the microseismic monitoring system, already installed at Gasifier 1 (see **Figure 21**).

- **Microseismic monitoring system**

A micro seismic system works by using geophones to detect microseismic activity from locations of brittle fracturing within the rock mass. Brittle fracturing in rocks produces seismic waves with low frequencies. It is expected that there will be fracturing as the gasification process takes place. This fracturing will mainly occur at the ~~-b~~oundary" of the gasification cavity. Some fractures will also be formed away from the gasifier. Locations of such fractures will be used to estimate the height of failure above the gasification cavity.

The system can also be used to determine fracture orientation during Aquasplitt™. It is important to know when goafing occurs as well as the size of the cavity at the time of goafing. This information will be used to validate the analytical and numerical methods. Back analysis can also be performed to determine "correct" input parameters for the models. As a result the numerical and analytical methods will represent reality more accurately. It will also be possible to determine if goafing poses any significant risks to the process.

The monitoring system comprises of four dedicated boreholes equipped with two geophones per borehole. In addition to the microseismic monitoring boreholes a similar setup was completed for the piezometer boreholes, equipped with multiple geophones per borehole. During any activity (drilling, linking, Aquasplitt™, etc.) at Gasifier 2, seismic activity will be recorded, this data will be interpreted and incorporated into the Geological Model.

- **Subsidence**

Subsidence beacons will be installed to verify baseline information with regards to any movement of the ground surface area in and around the Gasifier 2 area prior to any events.

6.1.3 Recommendations

Ongoing geological and rock monitoring programmes are required to ensure that a high level of geological certainty, reliability and assurance is achieved and maintained. The existing geological database should be continuously updated when new geological data is acquired. Record should be kept of all changes that are made over time.

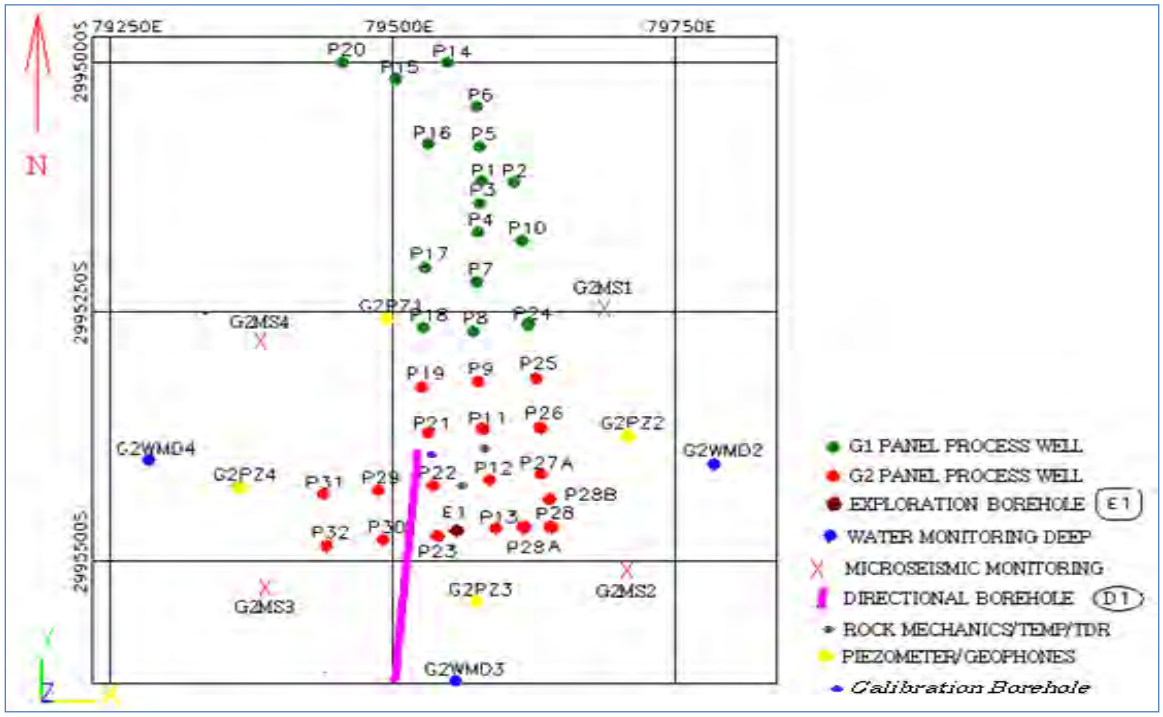


Figure 21: Borehole monitoring layout at Majuba UCG Gasifier 1 (Pilot Plant Phase 1)

6.2 Hydrogeology

Groundwater and surface water sampling programmes have been conducted at Majuba UCG since 2006. A monitoring procedure was developed in 2009 by Golder[18] for Eskom. **Figure 22** shows the distribution of groundwater and surface water monitoring points.

The recently drilled boreholes around the future proposed gasifier 2 (should it be approved) are constructed to monitoring the different aquifer units. These are not active operational boreholes at this time, but merely serve as monitoring points for the Pilot Plant Phase 1 in terms of potential contamination from the now-dormant gasifier process. Specifically the existing boreholes are as follows:

- Shallow – all WMS boreholes monitoring the shallow aquifer (± 40 m deep);
- Intermediate upper – all WIU boreholes monitoring the upper contact with the dolerite sill (± 120 m deep);
- Intermediate Lower – all WIL boreholes monitoring the bottom contact of the dolerite sill (± 170 m deep); and
- Deep – all WMD boreholes monitoring the Gus coal seam (± 280 m deep).

The aim of the sampling is to monitor the quality of the surface and the groundwater lying within the Gus coal seam about 280 m below surface and the shallow aquifer at 30 m below surface. It is known that UCG processes can a pose potential pollution risk to groundwater although it depends mainly on local hydrogeological conditions. The aim of the monitoring is thus to monitor and analyse the extent of the (potential) groundwater pollution originating from UCG processes. Groundwater pollution is caused by the diffusion and penetration of contaminants generated by underground gasification processes towards surrounding strata and the possible leaching of underground residue by natural groundwater flow after gasification.

Typical organic pollutants include phenols, benzene, minor components such as Polycyclic Aromatic Hydrocarbon (PAHs) and heterocyclics. The natural groundwater flow after gasification through the coal seam is attributable to the migration of contaminants. The extent and concentration of the groundwater pollution plume depend primarily on groundwater flow velocity, the degree of dispersion and the adsorption and reactions of the various contaminants. The adsorption function of coal and surrounding strata make a big contribution to the decrease of the contaminants over time and with the distance from the burned cavity.

[18] **Ibid.** *Footnote* 4.

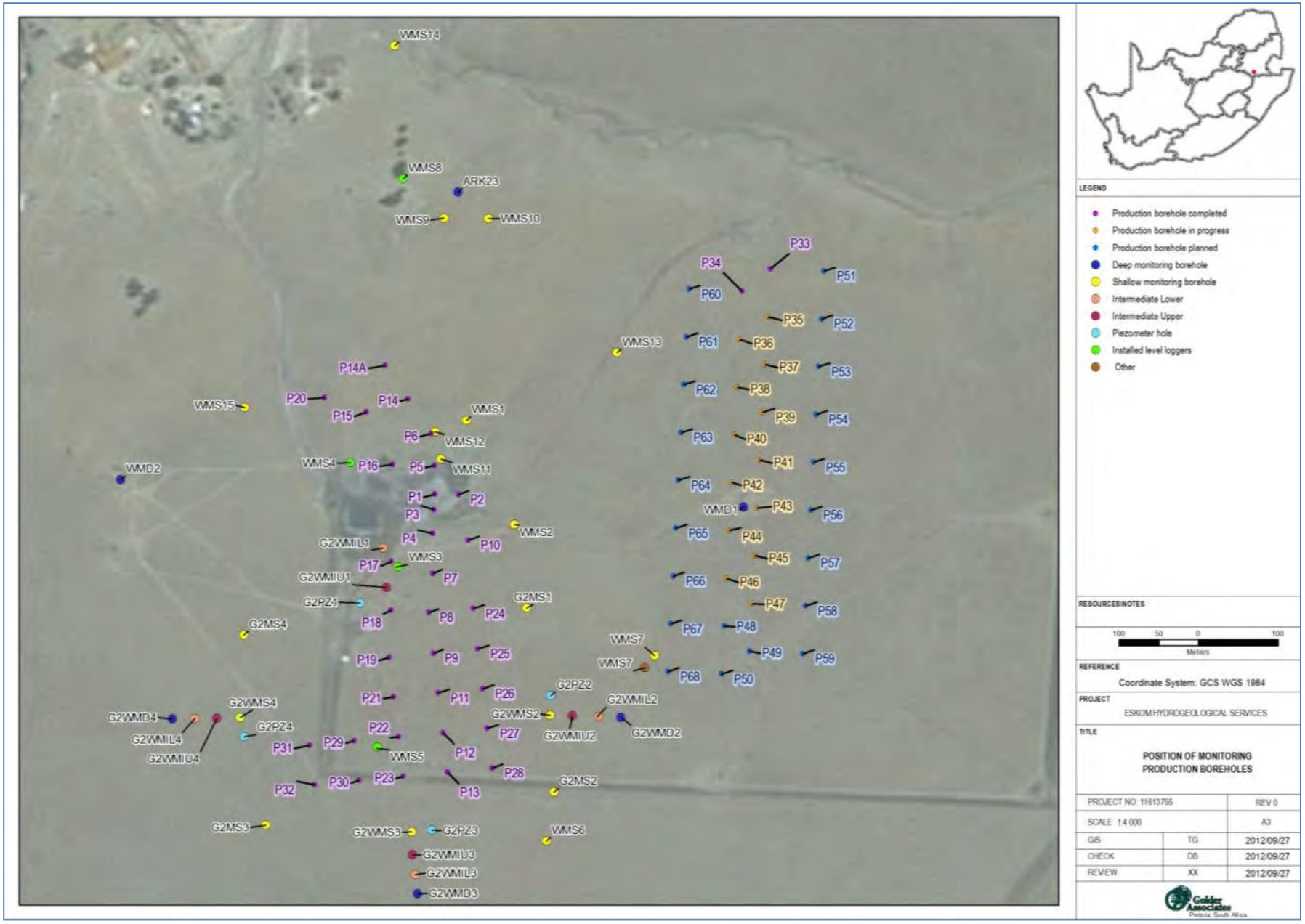


Figure 22: Position of boreholes and monitoring points

6.2.1 Groundwater Sampling

Groundwater samples were collected at fifteen (15) shallow monitoring boreholes (WMS1 – WMS15) and two (2) deep monitoring boreholes (WDM1 and WDM2). The positions of the monitoring boreholes together with the production boreholes are indicated in **Figure 22**. Shallow monitoring boreholes WMS7, WMS9 and WMS10 were drilled in June 2010 and sampling for WMS9 and WMS10 started during June 2010 and for WMS7 during July 2010.

The water quality analytical results are compared to the South African drinking water standards, SANS 241 of 2011 which provides the minimum assurance necessary that the water is deemed to present an acceptable health risk for lifetime consumption (this implies an average consumption of 2ℓ of water per day for 70 years by a person that weighs 60 kg). It is noted that SANS 241: 2011 standards do not have limits for magnesium, potassium, and calcium. In absence of standards in SANS 241: 2011 for these determinants, the SANS241: 2005 standard was used.

The Dutch standard was used to compare the organic chemical results and is listed in Appendix A of the Hydrogeology Report (**Appendix F**). These guidelines have been developed for the protection of drinking water and aquatic systems and are therefore considered appropriate for all water samples collected from the Majuba UCG site.

6.2.2 Incidents during the Monitoring Period

Two known incidents since commencement of the groundwater monitoring are noted:

- Surface diesel spillage occurred in early 2008 near shallow monitoring borehole WMS4.
- Production borehole P5 gas leak (**Figure 23**):
  - The incident occurred during May to September 2011.
  - The leak occurred in production borehole P5 due to casing failure and syngas leakage. It was detected in shallow monitoring boreholes WSM11 and WMS9 (drilled to depths of 25 and 18 m below ground level respectively). WSM11 and WMS9 are located approximately 10 and 100 m downstream, respectively from P5.
  - The gas migrated along the annulus of the casing until it reached the inferred fracture zone within the shallow dolerite sill above the groundwater table. It potentially migrated along the fracture within the unsaturated zone towards the north where it came in contact with groundwater near borehole WMS9.
- Eskom implemented air sparging as well as flushing of the soil and shallow aquifer system with clean water to remediate the impacted area successfully during September 2011 to November 2011.

An investigation was done to establish the root cause of the casing failure in the production well and to establish the nature, depth and severity of the casing failure in order that the well can be successfully repaired and permanently sealed off. The monitoring results indicate that the contamination area is less than five hectares (5 ha), which is less than 2% of the localised aquifer.

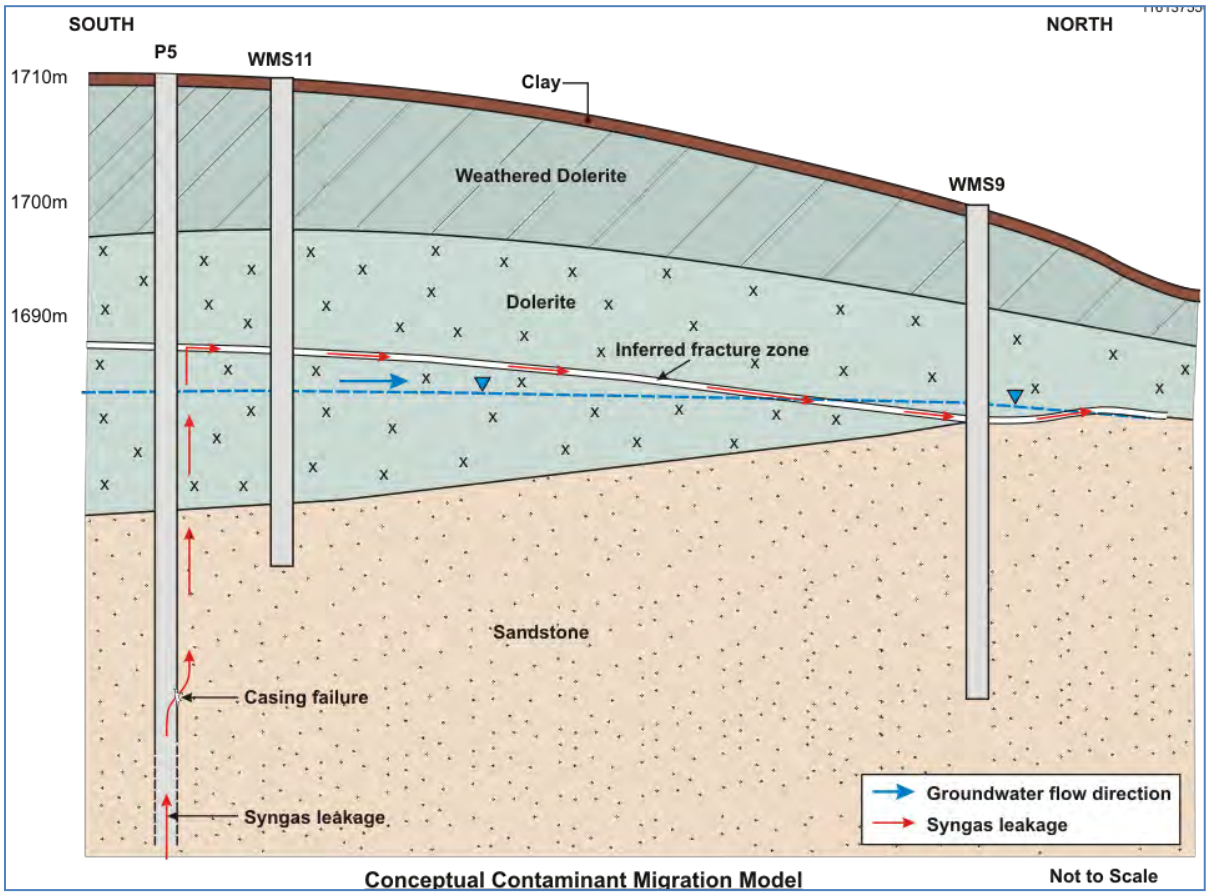


Figure 23: Conceptual contaminant migration model[19]

- ***Chemical composition of the potential contamination***

The condensate produced by the UCG process contains organic compounds typically found in the Gasoline Range organics (GRO's), some Polyaromatic Hydrocarbons (PAHs), Phenols and BTEX (Benzene, toluene, ethylene, xylene).

As part of the early detection water monitoring system, the following organic compounds were analysed on a monthly basis and the discussion included in **Section 6.2.4**:

- BTEXMN – Benzene, toluene, ethyl benzene, m+p-Xylene, o-xylene, 1, 3, 5 trimethyl benzene, 1,2,4 trimethyl benzene, Naphthalene, MTBE and TAME.
- PHENOL – Phenol, 2 chlorophenol, 2 nitrophenol, 2, 4 dichlorophenol, 2, 6 dichlorophenol, 2 methylphenol (o-cresol), 3- and 4-methylphenol (m+p cresol), 2, 4 dimethylphenol, 2, 4, 6 trichlorophenol, 2,4,5 trichlorophenol, 4-chloro-3-methylphenol, 2,3,4,6 tetrachlorophenol and pentachlorophenol.
- PAHs – Naphthalene, acenaphthene, acenapthylene, fluorine, phenanthrene, anthracene, pyrene, benzo(a)anthracene, crysene, benzo(k+b)fluoranthrene, benzo(a)pyrene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, indeno(123-cd)pyrene.

The major components in the raw produced UCG condensate are as follow according to concentration (parts per billion (µg/l).

[19] Golder Associates, 2013. Eskom Majuba Groundwater Monitoring Report. Report No. 11613755-11623-1.

- Phenol 3,200,000
- 4-methyl-phenol 620,000
- 2-methyl-phenol 220,000
- Benzene 18,000
- Naphthalene 29,000
- Toluene 2,000

It has been confirmed by analyses that the major components are present in some of the water monitoring wells at significantly reduced levels.

6.2.3 Inorganic Groundwater Quality

6.2.3.1 Synopsis of Shallow Aquifer Quality Trends

With the exception of boreholes WMS1, WMS7 and WMS11; total dissolved solids, sodium and chloride were reported low below SANS 241:2011 standards for all shallow aquifer boreholes throughout the monitoring term (2010 to August 2012).

High TDS was recorded for boreholes WMS1, WMS7 and WMS11 throughout the monitoring term. Similarly, the elevation of Ca, Mg, Na, Cl, F, NO_3, SO_4, were observed during specific times during monitoring in many of the boreholes but especially WMS1, WMS7 and WMS11. Most of the trace metals analysed was reported below the lab detection limit. Trace metals including Zn, Mn, Al, B, Ba, and Li were detected in shallow aquifer water samples. There seem to be an increasing trend (although at low concentrations) of trace metals and this trend needs to be observed over time, to apply precautionary measures if the problem persists.

From the data collected it is evident that the elevated levels of inorganic species in the groundwater are likely caused by dissolution of minerals associated with the Ecca Group sedimentary formations. However, geochemical characterisation will be required to unequivocally state that this is the case. It is further suspected that the gasification processes (changes in temperature and pressure) may enhance the dissolution to result in elevated salinity and trace metal content. These processes can be investigated by advanced geochemical modelling. The incident at P5 where there was a leakage and the subsequent remediation efforts of air sparging and water flooding; may also be related to the increase in contaminants. However, the quality of the water that was injected in the process void was not known (i.e. no base level for comparison).

The shallow aquifer water was characterised by plotting relative major anion and cation concentrations on a Piper diagram. The basis of piper plots is percentage plotting of cations and anions in separate triangles. The intersection of lines extended from the ion points to the central rectangular field gives a point representing a type of water. The disadvantage of Piper diagrams is that it excludes parameters such as NO_3, TDS, and Si in water characterisation.

The shallow aquifer water all plots in the centre to the left section of a diamond field, **Figure 24**, indicating no dominant cation but with the majority of samples being bicarbonate anion dominant. WMS11 water plots in the upper centre of a diamond field, showing enrichment of chloride relative to bicarbonate.

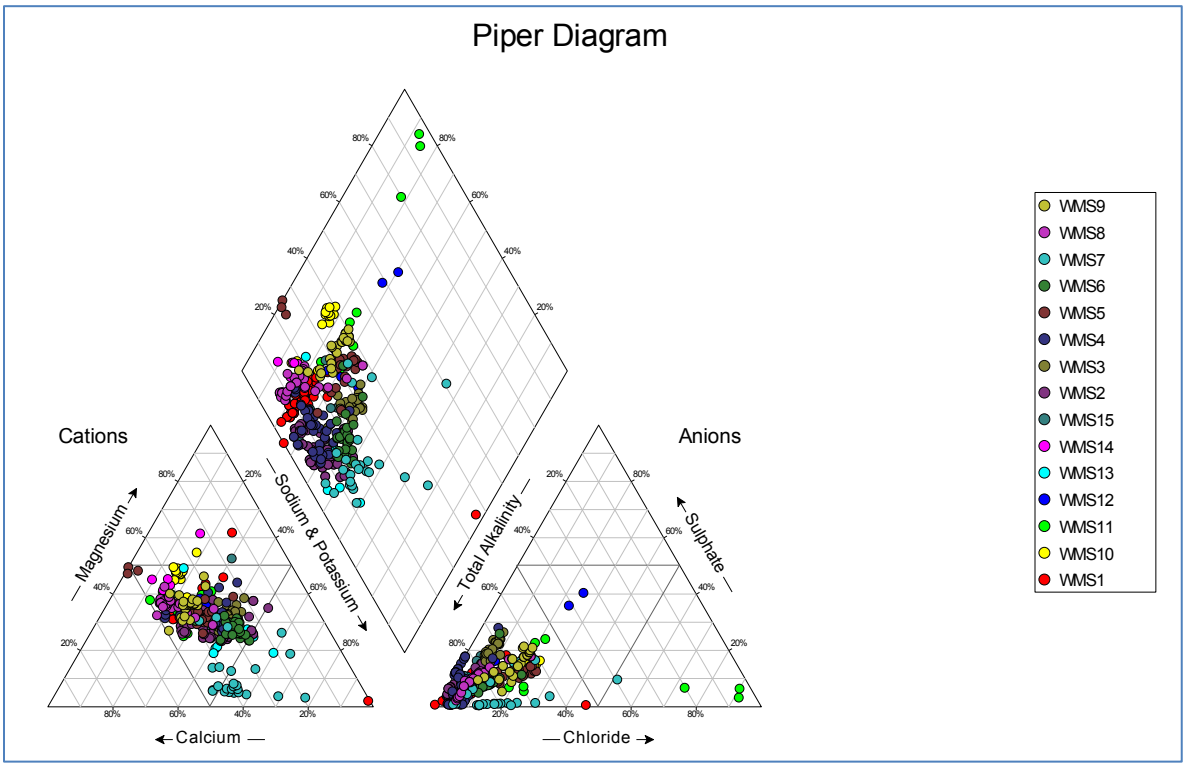


Figure 24: Piper diagram shallow aquifer water characterisation (2010 to 2012)[20]

6.2.3.2 Synopsis of Deep Coal Seam Aquifer Water Quality Trends

The dominating ions in deep aquifer water include Sodium, Chloride and Bicarbonate, resulting to high Total dissolved solids. Other cations present include Calcium, and Magnesium. Nitrates, Fluoride and sulphates are also present in low concentrations. The elevated levels of trace metals such as Mn, Fe, As, Se, Ba, Li, Mo and Sr are also present in deep aquifer groundwater. There is an increase in most of these trace metals during the July 2012 sampling event. The source of this is unknown need to be confirmed observed over time.

The hydrochemical data discussed above was plotted on Piper and Stiff diagrams to characterise deep aquifer groundwater and to establish the groundwater types. Piper diagram presents the cations and anions (as milliequivalent per litre) percentages as plotted in two triangular diagrams and both cations and anions extrapolated onto the central diamond field. This enables the water types and source of ions present in the water to be identified.

The water quality trends for deep coal seam shows elevated concentrations of TDS, sodium and chloride in both boreholes WMD1 and WMD2. The samples plot in a predominantly Na-Cl-bicarbonate section of the diamond field (**Figure 25**). The high salt levels are typical what is expected of deep coal seam water, however a geochemical characterisation of the host rock will be valuable to determine whether the elevated chemical parameters measured in the groundwater is caused by natural mineralisation or from external sources e.g. hydro-linking injection water.

[20] Ibid. *Footnote 19.*

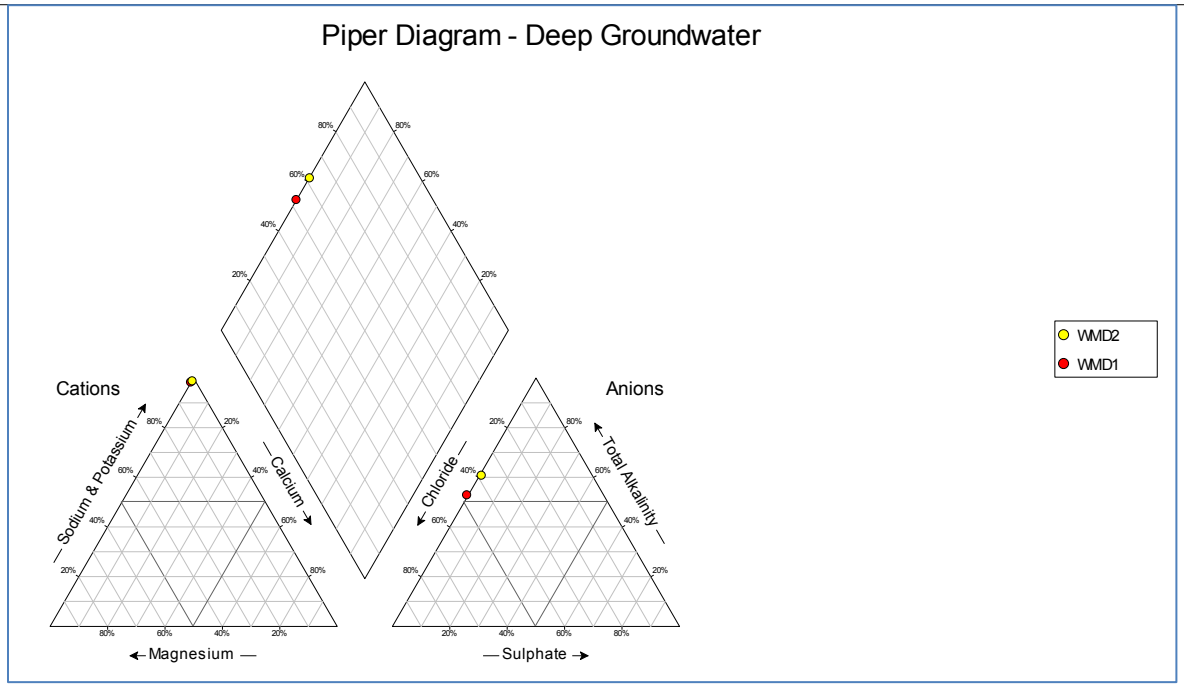


Figure 25: Piper diagram – deep coal seam aquifer[21]

6.2.4 Synopsis of Hydrocarbon Results

From the currently available organic sampling results, it is confirmed that boreholes WMS1, WMS2, WMS4, WMS7, and WMS9 are contaminated with organic pollutants. The source of contamination is related to the UCG processes on site. These boreholes are located downstream (with exception of WMS7) from where the incident in 2011 happened in P5. The contaminants were at the highest levels recorded in the time period between August 2010 and November 2011. This indicates that the leakage from P5 may have started earlier than the recording of the incident in May 2011.

Levels of contaminants decreased and stabilised in the next year, but an increase in concentrations are observed in the last part of the monitoring period – August 2012. The major contaminants of concern are volatile compounds BTEX and phenol as well as PAH contaminants especially naphthalene. The concentrations at which these contaminants are found are above the Dutch intervention levels, which would imply that it poses a risk to the environment and that intervention/remediation is required.

The two deep monitoring boreholes WMD1 and WMD2 remain consistent and mostly unaffected by the hydrocarbon contamination.

6.2.5 Groundwater Levels

Groundwater level measurements forms part of the groundwater monitoring programme implemented on site by Eskom. The water level monitoring seeks to explore the water level fluctuation and response to site activities. In this case both shallow and deep aquifer water levels were monitored.

[21] Ibid. *Footnote 19.*

6.2.5.1 Shallow Aquifer Water Levels

The shallow aquifer water level data trends are included in **Figure 26**. The shallow aquifer monitoring boreholes and latest water level data are listed in **Table 31**.

It should be noted that water level data reported may not be the true representation of the static water level condition on site but that of the site during the field measurements. Site activities such as water injection in attempt to clean the aquifers, pumping as well as abstraction requirement for hydrolinking affect the natural water level condition.

Table 31: Shallow aquifer groundwater levels

BH_ID	Date	Lat	Long	Elevation (mamsl)	SWL (mbgl)	SWL (mamsl)
WMS1	05/09/2012	-27.06447	29.80257	1681.4	34.2	1647.3
WMS10	05/09/2012	-27.06219	29.80282	1695.7	19.4	1676.3
WMS11	05/09/2012	-27.06490	29.80228	1709.3	26.6	1682.7
WMS12	06/09/2012	-27.06459	29.80221	1708.8	5.6	1703.2
WMS13	05/09/2012	-27.06370	29.80427	1695.7	24.9	1670.8
WMS14	05/09/2012	-27.06023	29.80176	1679.0	4.0	1675.0
WMS15	05/09/2012	-27.06432	29.80006	1708.5	26.0	1682.5
WMS2	05/09/2012	-27.06564	29.80311	1680.2	37.4	1642.8
WMS3	05/09/2012	-27.06612	29.80180	1685.1	28.3	1656.8
WMS4	05/09/2012	-27.06494	29.80125	1704.3	26.1	1678.2
WMS5	05/09/2012	-27.06816	29.80156	1689.3	1.8	1687.5
WMS6	05/09/2012	-27.06922	29.80347	1688.6	34.9	1653.7
WMS7	05/09/2012	-27.06712	29.80470	1712.1	5.2	1706.9
WMS8	05/09/2012	-27.06173	29.80185	1678.0	38.4	1639.7
WMS9	05/09/2012	-27.06218	29.80232	1696.6	19.8	1676.8

6.2.5.2 Shallow Aquifer Piezometric Surface and Groundwater Flow Direction

Groundwater levels in shallow aquifer boreholes are generally deep ranging between 20 and 39 mbgl. This was measured in the majority of boreholes during the monitoring in September 2012. However, in the vicinity of the stream located to the north of the site and the areas where there are no activities taking place especially to the south of the Gasifier 1 and the proposed future Gasifier 2, shallower water levels (1 to 20 mbgl) was measured.

The shallower levels were measured in boreholes WMS5, WMS7, WMS10, WMS12 and WMS14 and WMS5 (**Figure 26**).

The deeper groundwater levels were measured in boreholes WMS1, WMS11, WMS13, WMS15, WMS3, WMS2, WMS4, and WMS6; located in the vicinity of the production wells. There is an increase in water levels observed from September 2011 to November 2011 (**Figure 27**) and are due to water injected during the remediation of the P5 incident.

The water level data were used to prepare the groundwater piezometric and flow direction map. The flow direction across the study area is from the south to the north towards the stream located to the north of the site, as illustrated on **Figure 28**. In general, groundwater flows from the higher topographic area to the lower lying area, following the topographic gradient as expected.

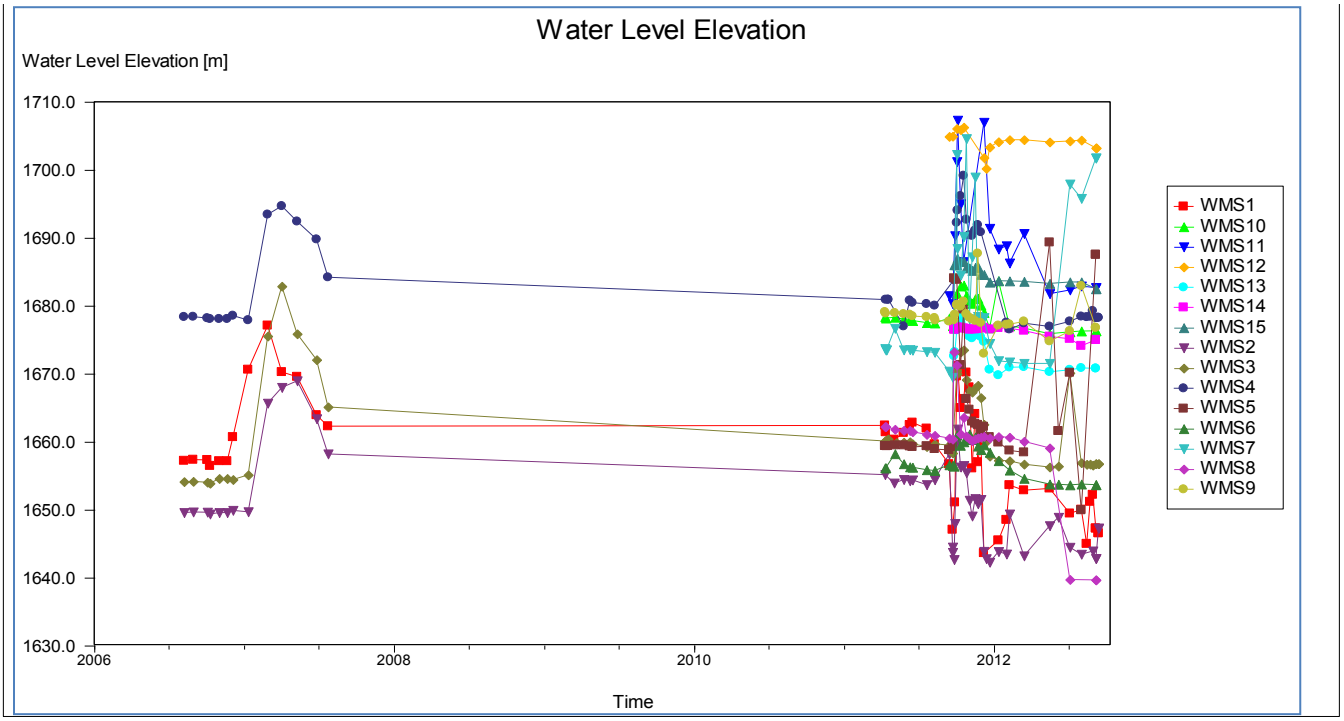


Figure 26: Shallow Aquifer Water Levels (2006 to 2012)[22]

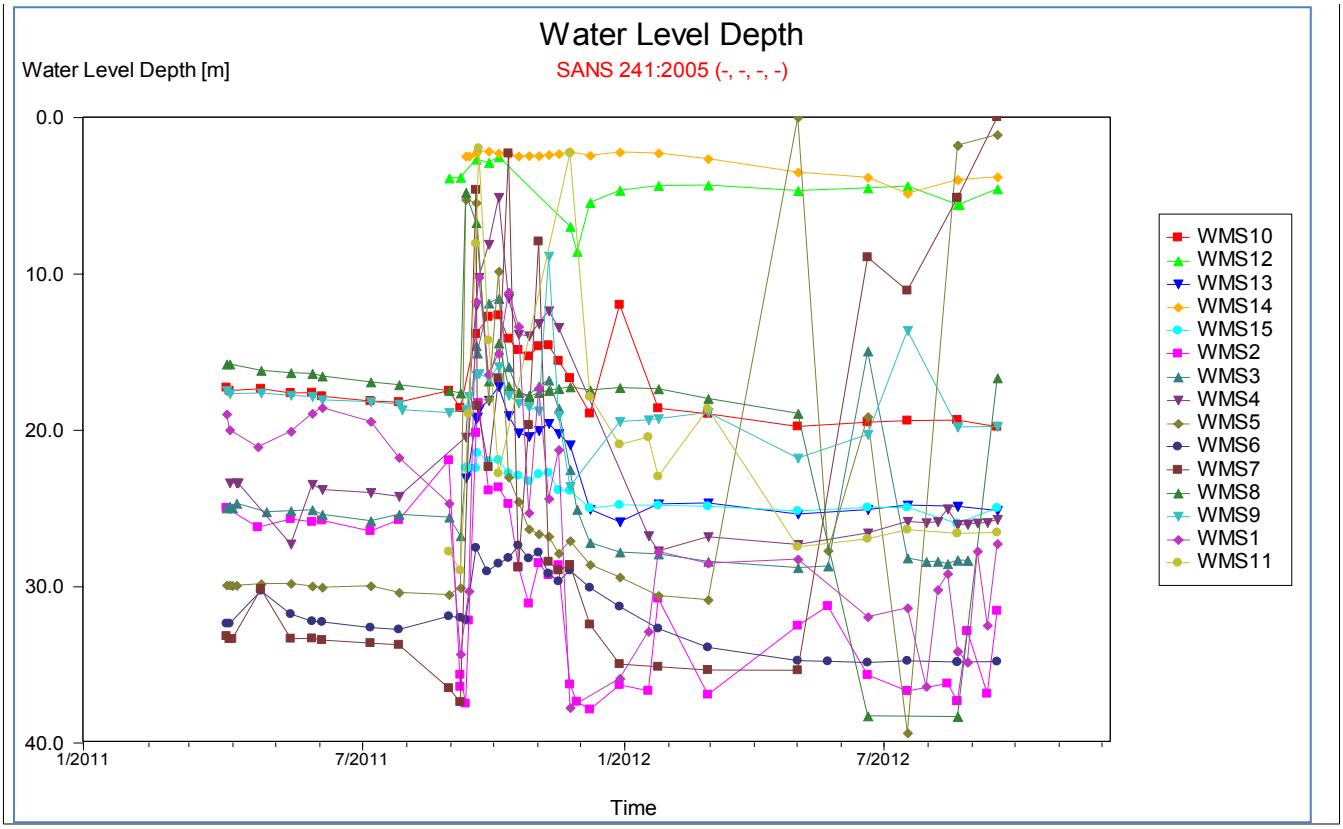


Figure 27: Shallow Aquifer Water Level Depth (2011 to 2012)[23]

[22] Ibid. *Footnote 19.*
[23] Ibid. *Footnote 19.*

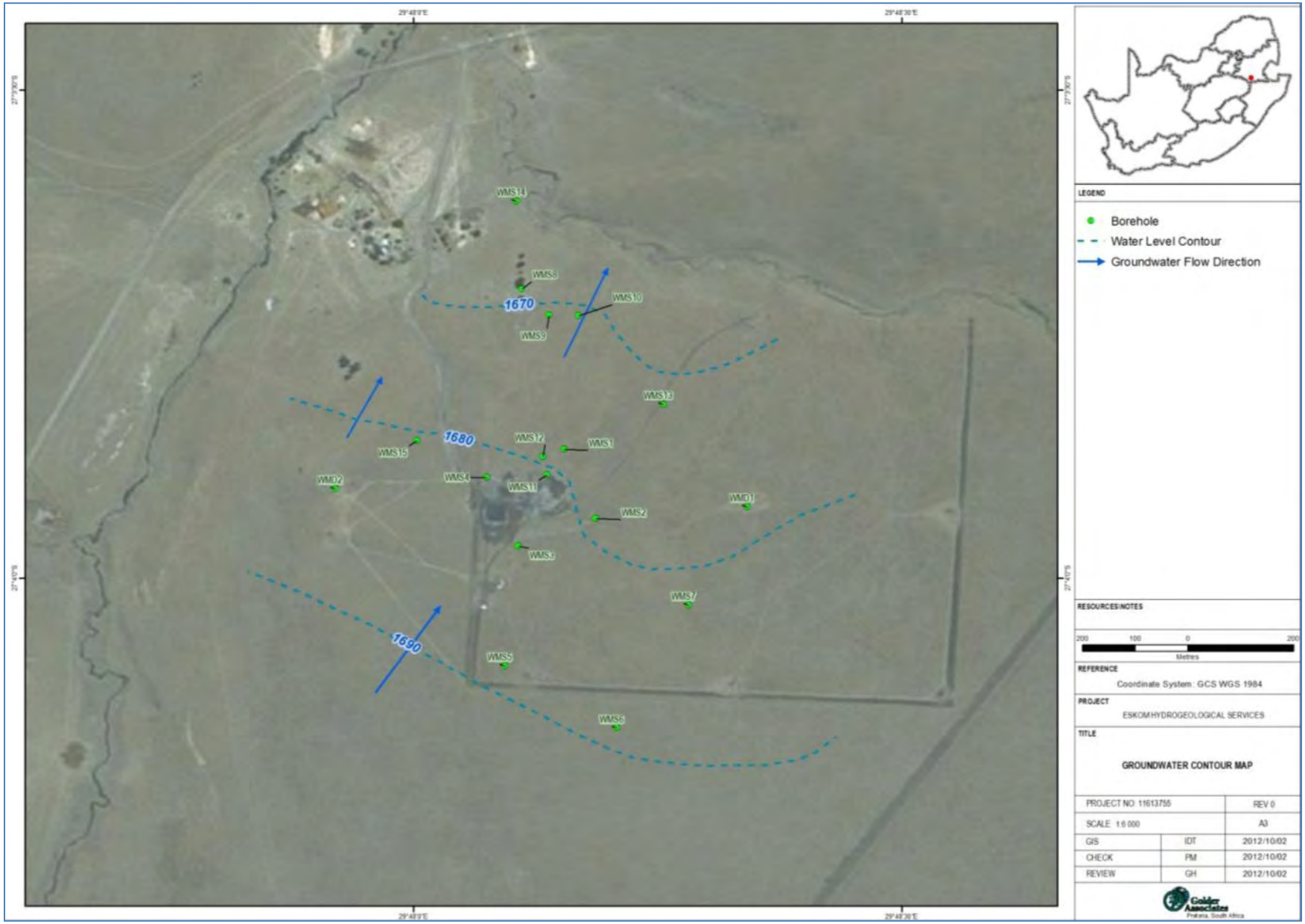


Figure 28: Groundwater piezometric level and flow direction map for the shallow aquifer (July 2012)

6.2.5.3 Deep Aquifer Water Levels

The deep aquifer water levels show an increasing trend since monitoring started to the last available water level in September 2012, **Figure 29**.

Both boreholes were artesian flowing due to pressure in the system since the beginning of the year in 2012. As a result, similar groundwater flow direction pattern as in the shallow aquifer is noticed for the deep aquifer, and the groundwater flow is from south to the north, towards the east west flowing stream to the north of the site. The latest deep coal seam water level data is included in **Table 32**.

Table 32: Deep coal seam water level

BH_ID	Date	Lat	Long	Elevation (mamsl)	SWL (mbgl)	WL_mamsl
WMD1	01/08/2012	-27.06545	29.80570	1679.1	0.0	1679.1
WMD2	01/08/2012	-27.06514	29.79866	1682.9	0.0	1664.5

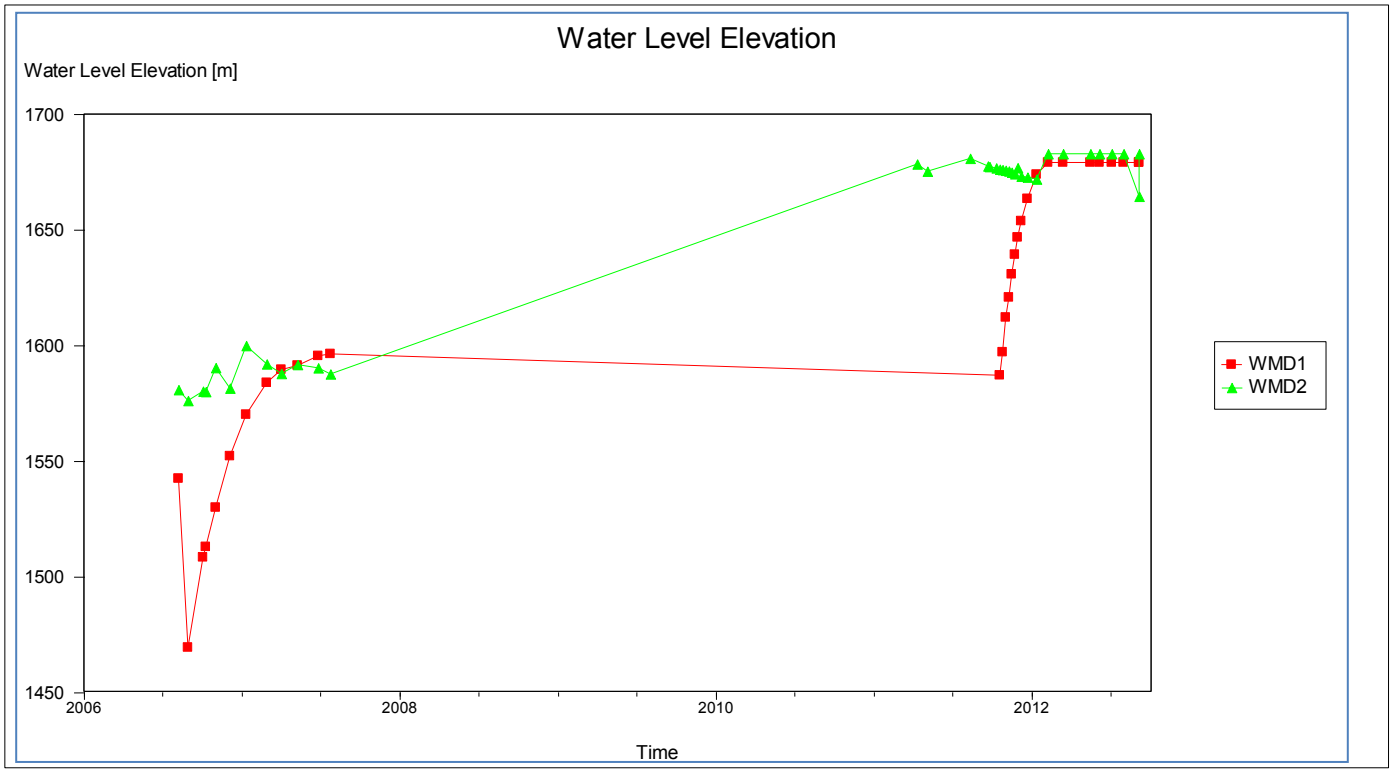


Figure 29: Deep coal seam water levels

6.2.6 Potential Impacts

Table 33: Potential groundwater impacts with respect to UCG project

Aspect	Key Environmental Issue / Potential Impact
Construction	
Shallow groundwater contamination	• Spillage of fuels, lubricants and other chemicals. • Construction equipment, vehicles, workshop and wash bay areas will be a likely source of pollution as a non-point source. • Lack of provision of ablutions that may lead to the conducting of informal ablutions. It is noted that to date the site has not experienced this and the behaviour of the staff on site is not likely to change at this time.

Aspect	Key Environmental Issue / Potential Impact
Operations	
Impact on shallow groundwater level	• Lowering of the shallow groundwater level in farmers' boreholes – note that as the Guss seam used is approximately 280 – 300 m below surface and thus this impact is deemed unlikely.(
Impact on shallow groundwater quality	• Contamination of the shallow groundwater quality.
Impact on shallow groundwater quality	• Failure of production borehole casings – the design / type of casings used is deemed critical.
Impact on the coal seam water level	• The gasification process consumes groundwater and an impact on the coal seam water level is expected. This water is below commonly used water resources.
Impact on the coal seam water quality	• The gasification process may impact on the quality of the coal seam groundwater, it is however noted that the water in the coal seam is of poor quality due to contact with the coal seam.
Irrigation of condensate and potential impact on shallow groundwater quality	• The condensate recovered from the gas treatment plant and gas pipeline is pumped into a process water dam (12,000 m^3). The dam is lined and has monitoring wells in place to provide an early warning system. UCG condensate from gasifier unit 1 has been piped to this dam. The condensate will be treated to a quality suitable to either: o Support local irrigation activities; o Re-inject the water into the coal seam aquifer; or o Purify to Majuba raw water quality requirements. • Golder[24] indicated potential quality for the irrigation water as having very high concentrations of sulphate (1,520 mg/l); fluoride (141 mg/l) and chloride (413 mg/l).
Overflow from contaminated storage dams causing an impact on the shallow groundwater quality	• As a safety precaution, a dam with sufficient capacity will be constructed in order to cater for down-time of the UF water treatment plant. Overflow of contaminated water from ponds may therefore have a negative impact on the shallow groundwater quality.
Leaks from pipelines	• Leaks of untreated water from pipelines may occur and impact on the shallow groundwater quality – note that to date no significant leaks have occurred and contamination checks indicate no localised pollution from the system.
Decommissioning/Closure	
Impact on the coal seam water level	• After the gasification process has shut down the impact on the coal seam water level will remain during the water level recovery period.
Impact on the coal seam water quality	• The gasification process may impact on the quality of the coal seam groundwater that will remain after closure – as indicated above the water quality to start would have been poor.

6.2.7 Groundwater Management Recommendations

Groundwater level and quality monitoring is an essential management tool and is strictly required for the validity of a water use licence. Water quality monitoring provides early warning signs about the status of the resource and it allows the development of mitigation strategies to be implemented when necessary.

The water resources (surface and groundwater) monitoring should continue at the Eskom UCG site and the following should be considered:

[24] ***Golder Associates; 2013.*** *Management Plan for the disposal of condensate water by irrigation. Report Number 11613755-11857-2.*

- Consistency in water sampling and groundwater level measurement dates is missing and should be established to allow data comparison. All the points (surface and groundwater sampling points) must be sampled consistently and analysed within the same sampling period to allow the establishment of seasonal variation and influence of site activities to groundwater levels and quality.
- The sampling procedure as detailed in Golder report 11600-8209-1[25] should be followed and sample contamination should be prevented at all cost by using the appropriate sampling equipment, bottles and latex gloves when necessary.
- The groundwater abstraction and injection records are essential and must be kept, to allow the establishment of the response of an aquifer to either pumping or aquifer recharge. This data would enable the explanation of groundwater level fluctuation occurrences, i.e. occasional water level drawdown and recoveries.
- The quality of water injected into the aquifer must also be analysed to allow the comparison of the injected water quality and groundwater analytical results. Similarly, the quality of water used during hydro-linking is essential and must be recorded for the same reason. Data on the volume and duration of injection must also be recorded.
- The proactive management and monitoring of fuel storage tanks is needed on site, and should include fuel spillage control, management and remediation. This will reduce the likelihood of incidents recurring.
- Surface water quality monitoring is very important in tracing the influence of the site activities to the quality of surface water resources and must continue in all surface water monitoring points (upstream, downstream, Witbankspruit and process water dam).
- The duration gap of groundwater and surface water quality data analysis and reporting should be reduced from 2 years to at least 6 months. This will allow reporting on the status of the water system half yearly and will allow Eskom to respond to the recommendations, so as to implement necessary controlling measures.

6.3 Hydrology

There are four surface water monitoring points (**Figure 30**) on site. The surface water was sampled consistently throughout the monitoring period from four points shown in **Figure 30**:

- The Witbankspruit (2010 data only);
- Upstream at a non-perennial stream (2010 – 2012);
- Downstream at a non-perennial stream (2010 – 2012); and
- The cooling water dam (2010).

The samples were collected by Eskom personnel and chemical analysis was done by the UIS laboratory. The analytical results from the surface water samples are compared against the Resource Water Quality Objectives (RWQOs) set out in **Table 34** or against the water quality guidelines[26] for irrigation and aquatic systems where RWQOs are not available.

[25] Ibid. *Footnote* 4.
[26] ***Department of Water Affairs and Forestry, 1996.*** *South African Water Quality Guidelines series.*

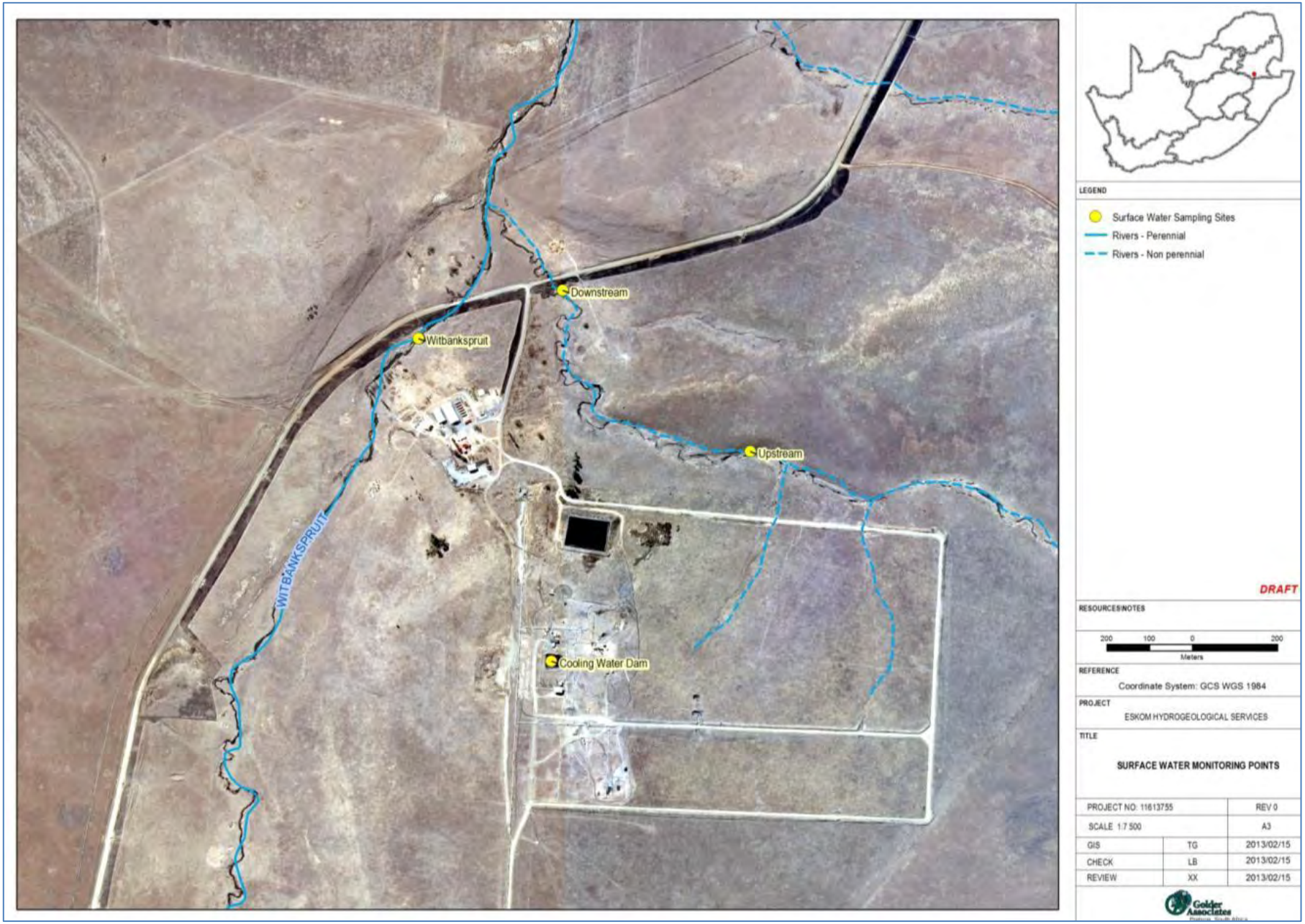


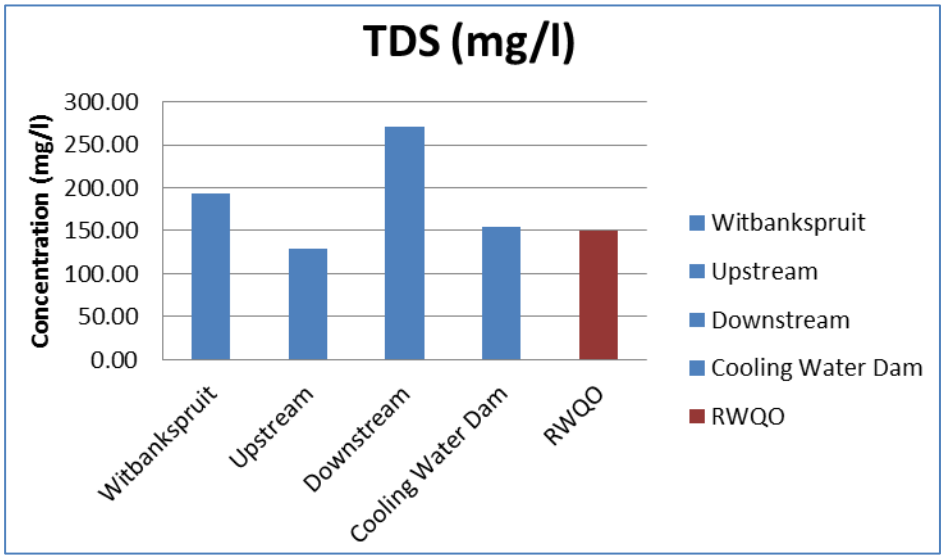
Figure 30: Surface water monitoring points

Table 34: Resource Water Quality Objectives: Grootdraai catchment

Variable	Unit	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 10	10 - 15	15 - 25	> 25
Alkalinity ($CaCO_3$)	mg/l	< 20	20 - 45	45 - 75	> 75
pH	pH units				< 6.4 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.08	0.08 - 1	> 1
Sulphate (SO_4)	mg/l	< 10	10 - 20	20 - 30	> 30
Nitrate (NO_3)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.02	0.02 - 0.5	0.5 - 1	> 1
SAR		< 4	4 - 8	8 - 12	> 12
Chloride (Cl)	mg/l	< 10	10 - 15	15 - 20	> 20
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 15	15 - 25	> 25

6.3.1 Chemical Water Quality

The average values are compared against the acceptable level RWQOs available (**Table 34**) or against the stricter of the water quality guidelines[27] for aquatic, irrigation or domestic water use. **Figure 31** indicates that there is an impact from the site with average TDS at the upstream monitoring point at a concentration of 127 mg/l and 257 mg/l at the downstream site. The same is noted for the average sulphate concentration of 25 mg/l and
37 mg/l at the respective up and downstream sites (**Figure 32**). The sampling also indicates increases at the



downstream site of alkalinity, calcium, chloride and nitrate.

Figure 31: Average TDS concentration at the four surface water sampling points

[27] Ibid. *Footnote 26.*

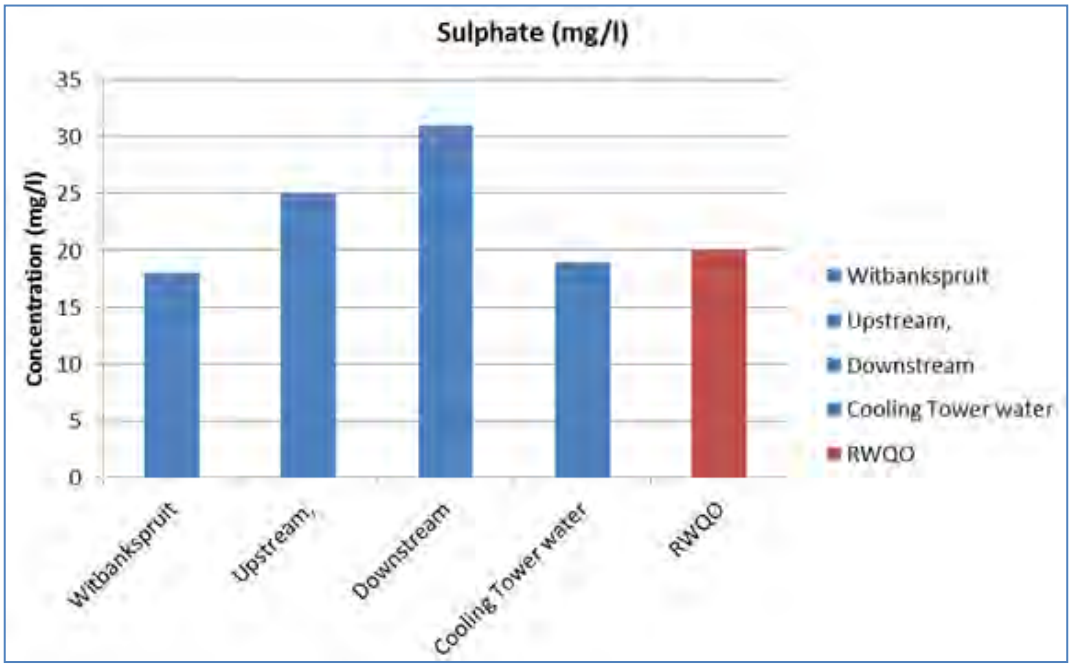


Figure 32: Average sulphate concentration at the four sampling points

6.3.2 Water Quality Trends

6.3.2.1 Witbankspruit

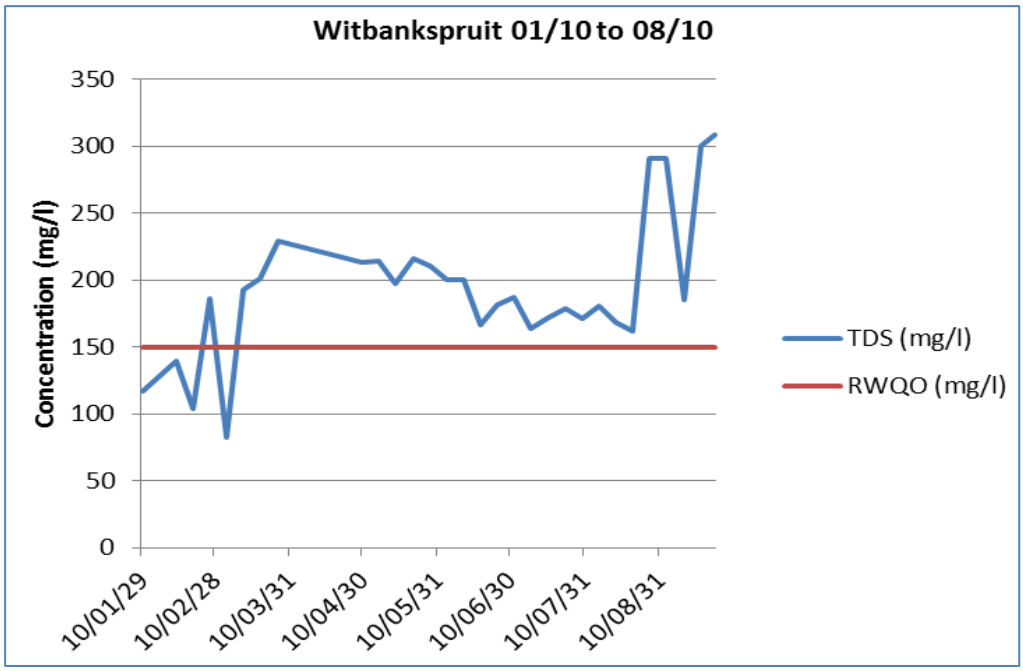


Figure 33: Witbankspruit TDS trends for the period January 2010 to August 2010

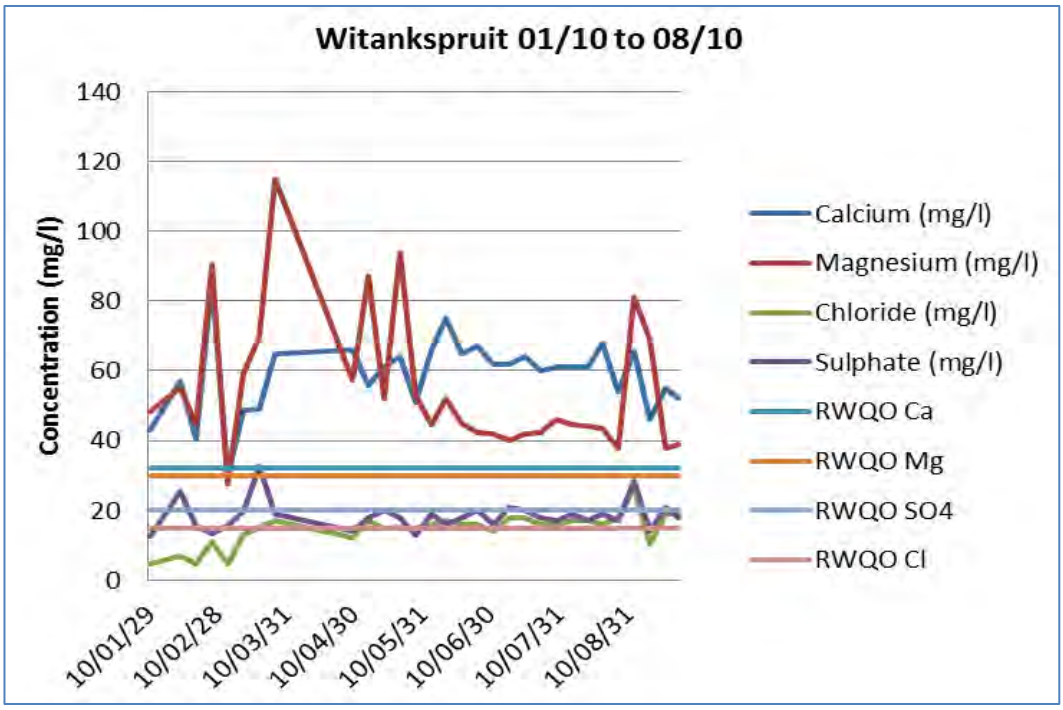


Figure 34: Witbankspruit water quality trends for the period January 2010 to August 2010

6.3.2.2 Upstream Sampling Site

Water quality for the period January 2010 to August 2010 indicated that the stream is being impacted on by upstream activities, very likely from overflows from the process water dam located east of Majuba Power Station (**Figure 35**).

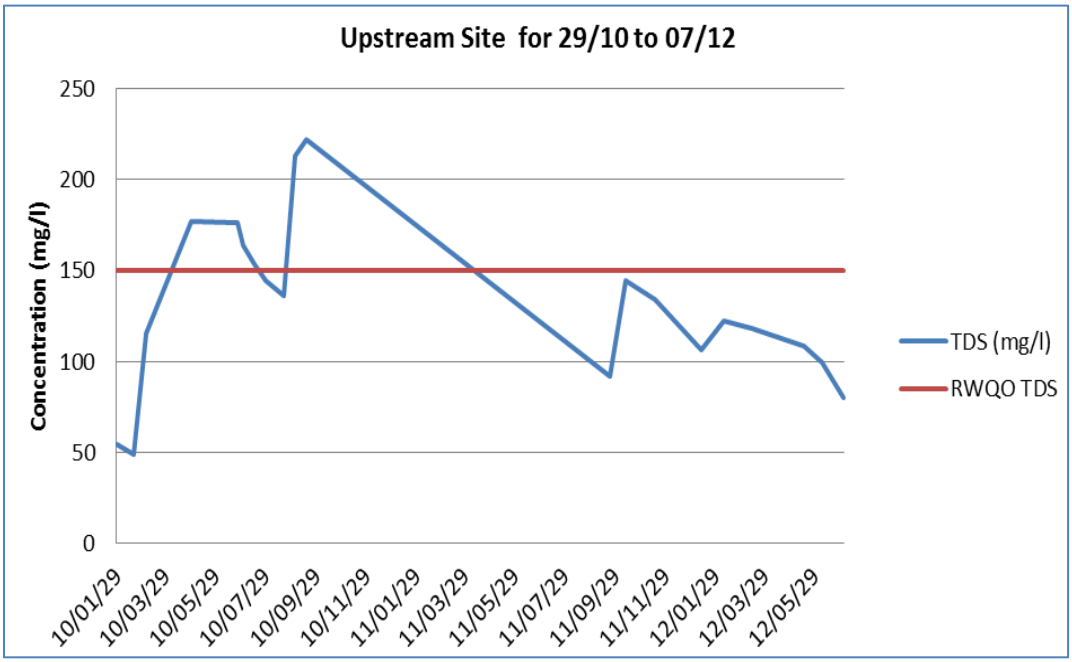


Figure 35: Upstream TDS trends for the period January 2010 to July 2012

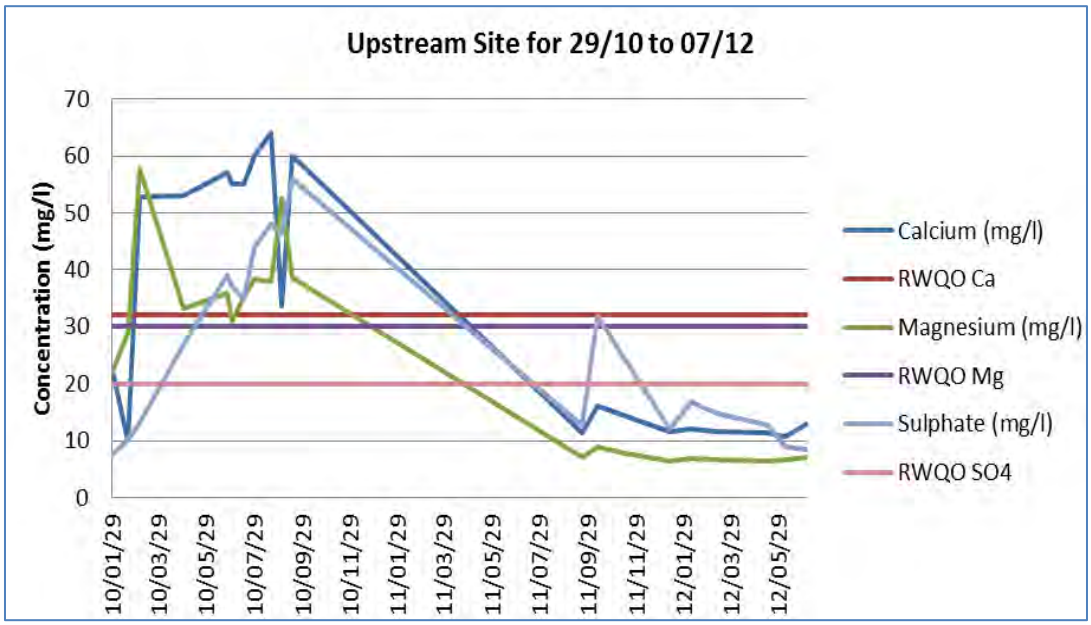


Figure 36: Upstream water quality trends (calcium, magnesium and sulphate) for the period January 2010 to July 2012

The water quality at the upstream site has improved considerably since May 2011. This would indicate that amongst other factors, the mitigation measures in operation are halting further contamination, as well as potentially reducing background contamination.

6.3.2.3 Downstream Sampling Site

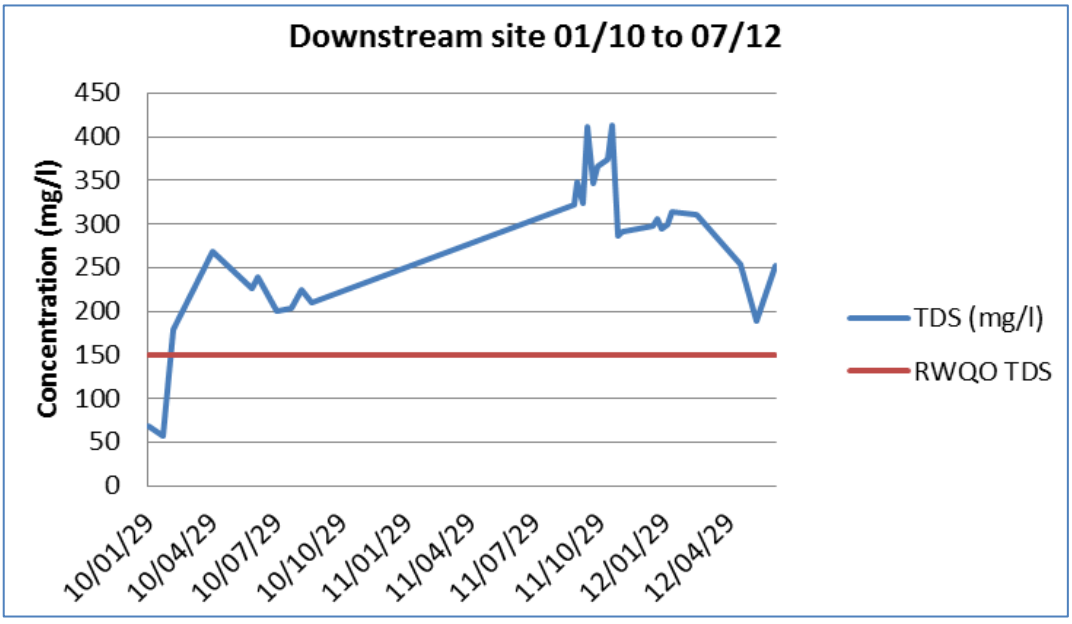


Figure 37: Downstream TDS trends for the period January 2010 to July 2012

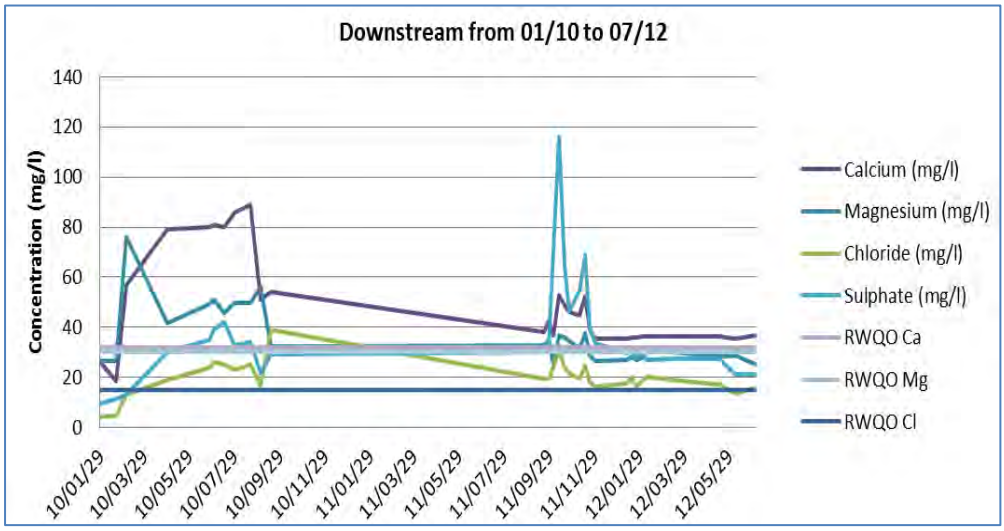


Figure 38: Downstream water quality trends (calcium, magnesium and sulphate) for the period January 2010 to July 2012

6.3.3 Potential Impacts

The potential surface water impacts from the project, both direct and indirect, are summarised in **Table 35**.

In summary these potential impacts contribute to overall surface water impacts of:

- Surface water quality; and
- Erosion of the streams due to potential run-off and discharge.

The surface water quality impacts will ultimately impact on the downstream water users.

Table 35: Potential surface water impacts with respect to UCG project

Aspect	Key Environmental Issue / Potential Impact
Run-off (roads, buildings, paving)	• Spillage of fuels, lubricants and other chemicals • Flow modification due to increased run-off
Discharge of treated water to a water resource	• The discharge of treated wastewater may affect the quality of the resource to which it is discharged and may therefore impact on downstream water users • Erosion of the watercourse may occur due to the discharge • Flow modification due to discharge
Overflow from contaminated storage dams	• Overflow of contaminated water • Flow modification due to spillages
Subsidence	• Subsidence could conceivably result in a ‗ridge' or embankment forming within part of the wetland's immediate catchment whereby the ‗upslope' areas could be lower than the downslope areas. This effect could significantly disrupt the overland flow of water from the upslope catchment into the wetland, which due to the highly vertic soils across much of the study area is the most important aspect of the hydrology of wetlands and their catchments. The subsidence may prevent water which would normally move downslope through colluvial processes towards the wetland from reaching the wetland. This subsidence may also conceivably have an impact upon the discharge of shallow groundwater to hillslope seepage wetlands in the area. Note that the potential for subsidence is still under investigation and forms part of the outcomes of the research investigation outputs of the Pilot Plant Phase 1.

6.3.4 Recommendations

In order to ensure that the medium to high impacts are mitigated a stormwater management plan has been compiled for the project to meet the requirements of Regulation 704 of the National Water Act (No. 59 of 2008). Flood line delineation will help to ensure that the mine keeps all new infrastructure out of the 1:50 flood line.

During construction and operation the surface water monitoring programme must be kept in place and be implemented until after decommissioning. Monitoring should be done on a monthly basis for all the parameters that are currently being undertaken and any further requirement / condition that would be written into the water use licence.

6.4 Freshwater Ecology

The proposed development area is transversed by the Geelklipspruit River catchment, quaternary C11J, with 8 significant seasonal drainage tributaries, which includes the Witbankspruit River (**Photograph 13**). These seasonal rivers can be characterised as small (1 – 2m) drainage lines that is formed by the low-rolling hill geology of the proposed development areas landscape.

As a result of these drainage lines being small, as well as consistent with the reference class conditions of the study area in general, these drainage lines or catchment tributaries does not have any significant riparian zones, but rather a seep/valley bottom wetland habitat composition. In terms of anthropogenic factors characterising the proposed development areas river and wetland features, the study area as well as the proposed development site remains in a rural setting, with all water features displaying agricultural based land use impacts (vegetation transformation caused by farming practise and stock, as well as damming of natural wetland depression for water use).

Photograph 13: Geelklipspruit River (Note that no riparian zone is evident and that the habitat is homogenous – characteristic grassland rivers of the Upper Vaal WMA)

6.4.1 Habitat Integrity

The evaluation of Habitat Integrity (HI) provides a measure of the degree to which a river has been modified from its natural state. Only one (1) Index of Habitat Integrity (IHI) assessment was undertaken due to all the potentially affected water resources residing in the same hydrogeomorphic zone (quaternary) and system drivers and pressures consistent throughout.

The following should be considered from this assessment:

- The impacts on the habitat are largely as a result of past flow modification practice, such as a degree of channel straitening, wetland channelization and in-channel damming as well as a superficial degree of water quality impairment.
- Other impacts associated with channel and flow modification are erosion related and past agricultural uses.
- Land degradation due to non-utilisation over time and old uses without rehabilitation has shaped this catchment within the study area as a moderately to largely transformed quaternary.
- However, the most significant consideration to the state of habitat integrity in this reach is the apparent sensitivity of these surface water resources to inducing erosion.

The IHI assessment estimated the proposed development sites ~~-ri~~ver features" to be in a **C-class** (Moderately modified - a loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged) for its instream integrity and in a **D class** (Largely modified – a large loss of natural habitat, biota and basic ecosystem functions has occurred) for its riparian integrity. The results conclude that associated impacts of past and current agricultural use as well as mismanagement of flow modification practice (channel, flow and water quality modification practice) has led to a largely modified system where ecosystem functions are relatively fair instream and relatively in a poor state across the riparian zone.

6.4.2 Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity Assessment analysis regards the development site's river features as highly important. The reason for this high score is not related to the biological composition of the sampled drainage areas, but do to the catchment being classed as a FEPA as well as being very sensitive to erosion.

6.4.3 Riparian Vegetation

The riparian marginal zone was not comprised of any true riparian indigenous vegetation. Common grass (*Cynodon dactylon*) and kikuyu grass species (*Pennisetum cladestinum* and *P. seraceum*) – were the only vegetation found in this zone besides indigenous instream sedge species *Juncus spp*. and *Phragmites australis*.

As a result of the river features not having a discernible riparian zone, the extent, structural and compositional integrity was deduced by inferring the assumption that the associated valley-bottom wetland extent of this riparian zone demarcated the zone itself and the parameters for assessment. Even so, no clear riparian or wetland species were found on the riverbanks as terrestrial grassland predominated in the midst of alien weedy grass species induced by past agricultural uses). However, a significant distribution of *Crinum spp.* were found throughout these wetland riparian zones indicated that some degree of wetland biology remains and that some ecological processes are distinct to the neighbouring terrestrial areas.

The ecological status of the site was analysed as Class D – Fair / Poor (Largely modified – a moderate to large loss of natural habitat, biota and basic ecosystem functions have occurred) which indicates a moderate to largely

modified riparian zone state often associated with multiple disturbances or consistent medium scale disturbances coming into the system. A moderate to large loss of natural habitat, biota and basic ecosystem functions has occurred. This is primarily due to the impacts of land-use pressures over time onto the system as well as the associated with agricultural based stream modification practice.

6.4.4 Wetlands Status Quo

The Present Ecological Status (PES) method was used to establish the integrity of the wetlands in the study area based on the modified Habitat Integrity approach. The habitat integrity assessment confirms modifications to the system and results in a **C-classed** (moderately modified, but with some loss of natural habitats) assessment for the proposed development area's wetland drainage features and a **D-classed** (largely modified – a large loss of natural habitats and basic ecosystem functions has occurred) assessment for the floodplain wetlands (valley-bottom wetlands).

6.4.5 Ecosystem Services

The assessment of the ecosystem services supplied by the identified wetlands was conducted according to the guidelines as described by Kotze *et al*[28]. The characteristics scored for the wetlands (**Figure 39** and **Figure 40**) according to the general levels of services provided are notably important and requires management to the wetlands to ensure that they can continue to provide the valued goods and services:

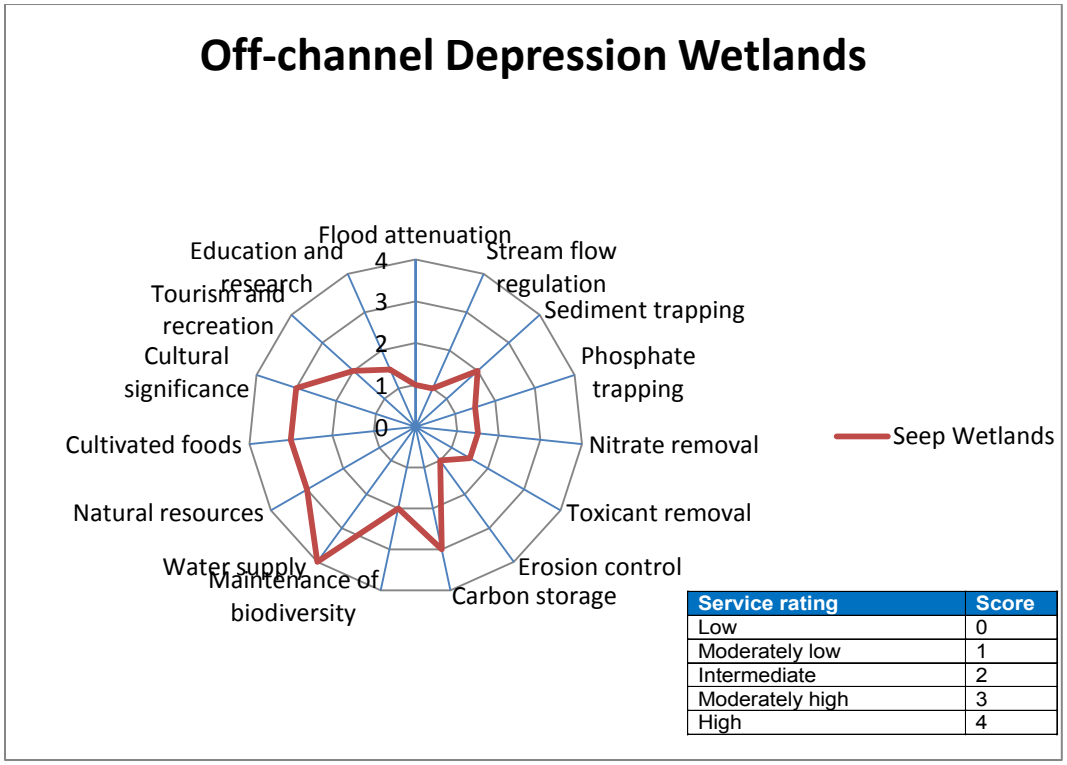


Figure 39: Radar graph of proposed development site off-channel depression wetland features ecosystem goods and services

[28] ***Kotze, D., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. and Collins, N.B. 2005****. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. Dept. Tourism, Environmental and Economic Affairs, Free State.*

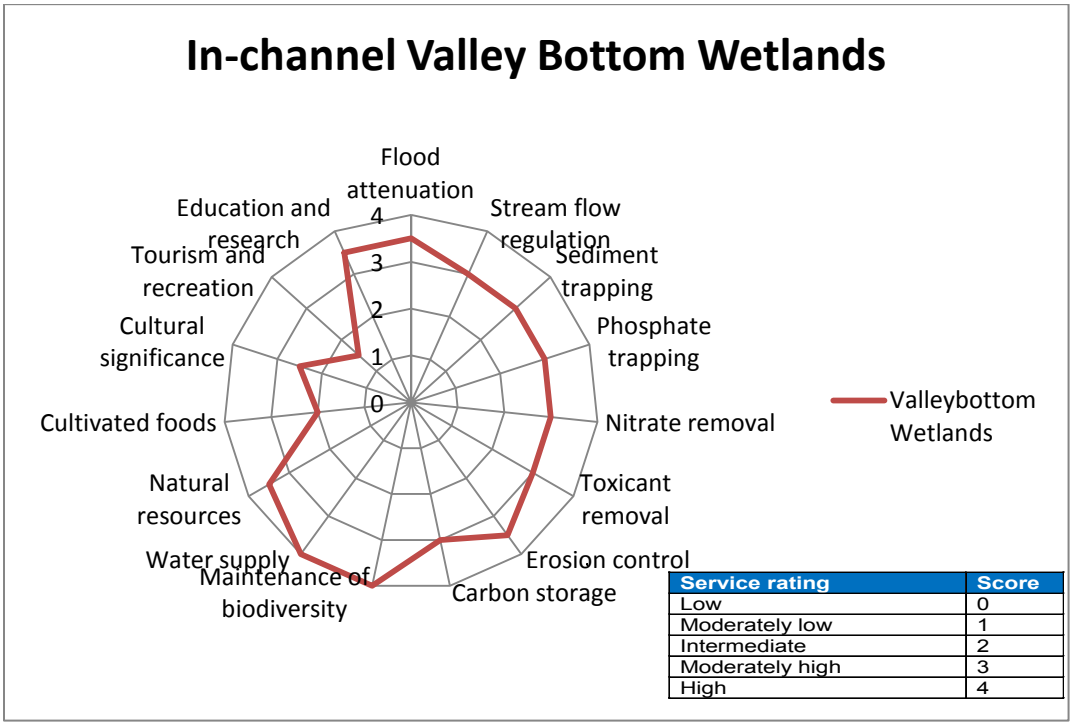


Figure 40: Radar graph of proposed development site's in-channel valley-bottom wetlands ecosystem goods and services

6.4.6 Potential Impacts on Surface Water Resources

Potential impacts associated with the proposed development on the receiving sites freshwater environment includes: water quality impairment, flow modification and loss of riparian habitat and bed / bank modification. Disturbance drivers include stormwater management structures from hard surface development (roads, buildings, paving) as well as associated water quality impacts and erosion induced practises (development mismanagement).

- ***Water Quality Impairment***

In a direct sense, water quality impacts by construction equipment, vehicles and material will be a likely water quality impairment point source. From an indirect and non-point source, run-off of building materials (e.g. cement) into the river during construction of the hard surface development structures/bridge is also possible.

- ***Flow Modification***

Infilling and compacting of soil layers covering the hard surface development structures is likely to alter the sub-surface flow from the terrestrial surroundings to the river as well as the flow through the channel banks. This may cause the river flow to increase or be impeded. Nevertheless, the erosion potential of the river will be compromised and is likely to cause erosion at the point of infilling or downstream of such point. However, this is seen as a small surface area impact as well as only short term.

- ***Loss of Riparian Habitat and Bed/Bank Modification***

Localised moderate to high impact – loss of aquatic habitat integrity and bed/bank modification could occur as a result of the proposed development, but again on a small footprint area. This impact is expected to be low due to the modified state of the river features found on site. Again the greatest risk with the proposed development is

stormwater management related and in the absence of a stormwater management plan dictating riparian bank cover, exposed banks can lead to site channels being further eroded and potentially vulnerable to alien invasive plant establishment.

- ***Cumulative Impacts***

The cumulative impact for this proposed development area is also erosion-related. The surface water features studied in this report was largely homogenous, but very sensitive in terms of its channel and bank stability. With effective implementation of the EMPr, the proposed development can be maintained at an acceptable level.

6.4.7 Recommendations

All surface water resources that will be directly built on as part of this proposed development must be registered as part of a positive endorsed water use license. In addition, compliance with the WULA conditions must be adhered to in a stringent and professional manner.

The study area and proposed development areas surface water resources have been qualified as highly important and sensitive, but in a moderate to largely modified ecological state. However, as with the wetlands found on site, these ecological ratings are not strongly correlated with the biodiversity importance of the area, but with the upstream location of these systems (upper Vaal River WMA tributaries forming part of river FEPA areas).

The risk associated with the mismanagement of these surface water resources are significant and important to maintain in an ecologically sound condition.

6.5 Wetlands

6.5.1 Wetland Units and Reaches

Once the delineation of wetlands was complete during the Scoping Study, the wetland shapefile was divided up into a number of wetland ‗units'. The primary factor used for classifying wetland units was the hydrogeomorphic type of the wetland. Units were also delineated based on physical factors such as the presence of a road crossing the wetland. For the purposes of the wetland functional assessment, the study area's wetlands were divided up into a number of ‗*reaches*'. A wetland reach typically consisted of a number of wetland units. It would have been impractical and counter-productive to undertake a wetland functional assessment for each wetland unit in the study area, and thus wetlands with a common characteristic were grouped into a reach.

Each reach was assigned a number based firstly on the sub-catchment in which it falls and then a number was assigned to that reach e.g. R_Skulp_1, R_Geel_5. It should be noted that the naming system was based on the former larger study area and thus certain wetland reaches will no longer appear in the list of study area wetlands.

6.5.2 Wetland Functional and Wetland State Assessment

Wetland functionality was assessed using the WET-EcoServices methodology developed by Kotze *et al*[29]. This methodology has been developed as a tool to identify the different aspects of functionality offered by a wetland. Wetland functionality is multi-faceted and includes a number of different but interlinked aspects such as hydrological functionality, ecological functionality, and socio-cultural functionality.

[29] Ibid. *Footnote 28.*

The WET-Health methodology is a tool that has been designed by the Water Research Commission to assess the health or integrity of a wetland. Health of the wetland equates to wetland state as referred to in this study.

The various categories of wetland state used by Wet-Health have been adopted for this study. These are:

- Natural;
- Largely natural;
- Moderately modified;
- Largely modified;
- Extensively modified; and
- Critically modified.

A detailed description of the wetland functionality and state for the study area wetland reaches is provided in the Wetland Report (**Appendix H**). A summary of the findings is provided hereunder.

6.5.3 Overall comment on Study Area Wetland Functionality, Pressures and State

A review of all of the wetland reaches assessed indicates that there are a few aspects of wetland functionality that are common to most wetlands in the study area. The first aspect is erosion control. In spite of their condition / state, one of the highest-scoring ecosystem services in the Wet-EcoServices assessment was erosion control.

This is a result of a number of factors, most important of which are:

- The high erodibility of the dominant soils (vertic soils);
- The relatively high degree of overland flow that tends to occur in the study area once soils become initially saturated and thus relatively impermeable; and
- The relatively good vegetation cover in the wetlands in the study area.

In most of the wetlands assessed, the vegetation cover in the wetlands was noted to be high. This is a critical factor in preventing loss of erodible soils. Luckily the nature of land use in most parts of the study area has entailed that there has been a relatively low human impact footprint in the wetlands in the study area.

However, one factor is counteracting this; the vast majority of disturbance of soil in the wetlands within the study area relates to the presence of livestock, in particular cattle. In most cases, a direct link between the effects of cattle trampling (that results in the destruction of wetland vegetation cover and thus the corresponding exposure and desiccation of wetland soils) was evident at active headcuts and in areas of accelerated bank erosion. The presence of water exacerbates the problem; cattle are drawn to these ‗wetter' parts of the wetland to both drink and graze the vegetation which is naturally greener than surrounding areas. The wet soils are easily trampled, and the presence of actively flowing water allows exposed soils to be easily washed away. These parts of wetlands are often critically important in biodiversity context as they are typically areas of diverse and often moribund vegetation, providing important habitat for a number of faunal and floral species.

It should be noted that the density of cattle on the site is markedly lower than on many similar farms across the Highveld and does not come close to the high-density farming operations controlled by the EIA regulations. Nevertheless the implications of the presence of the cattle on the farm are noted and given that the presence of the cattle on the site is not necessary, it is deemed better to remove them from the site and allow a more natural vegetation pattern to re-establish over time.

In the light of the above it must be noted that cattle, and more importantly the likely overstocking of cattle in parts of the study area, is the single most important degradation factor in wetlands in the study area. The removal of

livestock from parts of the area, if these areas are to be ‗mined' through the UCG process would likely be beneficial for the wetlands in the study area, as discussed below. However the impact of cattle on wetland functioning should be contextualised; the predominant land use in the area – livestock rearing – has allowed much of the study area to remain in a largely natural condition, and thus has allowed many of the natural ecological linkages and processes to be maintained. This context can be compared to a context of other types of land uses such as extensive cultivation or forestry, urbanisation or mining where the level of transformation of the landscape is much higher.

The nature of the interrelationship between land use (livestock rearing) in the area and wetlands is illustrated in the importance of wetland areas to livestock. The nature of the climate in the area, i.e. the highly seasonal rainfall pattern and the very cold, frosty winters has an impact on the dry season / winter-time availability of both water and fodder for cattle. There is typically very little rainfall in this time and the presence of frosts result in vegetation die-off and a resultant decrease in the amount of protein available for livestock in the veld. In these dry winter months, wetlands are typically the only natural source of water and fodder for cattle, as wetland grasses tend to stay greener for longer into the drier months, and tend to display the first emergence of green shoots before the onset of the rains.

The groundwater-fed nature of many wetlands in the study area is thus a critical factor contributing to the ecosystem services in this regard. Wetlands and the associated rivers into which they feed are an important source of water for cattle. The presence of groundwater-fed baseflow that occurs in these rivers and wetlands year-round is an important factor in sustaining the livestock rearing industry. This hydrological characteristic of rivers and wetlands is also critical for sustaining the biodiversity in wetlands, especially aquatic species and certain plant species which rely on wetlands being permanently inundated.

This ‗maintenance of biodiversity' ecosystem service is very important to the conservation of fauna and flora in the study area. As noted earlier in **Section 4.1.9** many of the wetlands that are permanently or highly seasonally inundated contain (often extensive) stands of the grass *Leersia hexandra*. These stands of this grass provide habitat for the Red Data-listed butterfly *Metisella meninx*, and are thus a critical component of the natural habitat in the study area. Other important species, especially certain large bird species like storks, flamingos and Marsh Owls were identified within wetlands in the wider area (former study area). In this context, the less common wetland types such as floodplains and wide un-channelled valley bottom wetlands are very important as habitat for these species. It should be noted that many of these less common wetland types are limited to areas of sedimentary geology, and thus wetlands underlain by geology of this type should be prioritised for protection.

Geology plays a similarly important causal role in another important factor of maintenance of biodiversity, i.e. the ecological linkage that exists between wetlands and their surrounding catchments. Areas where natural grassland catchments still exist in a largely intact state in the catchment of wetlands are typically underlain by dolerite geology. The widespread outcropping of dolerite bedrock as well as the presence of strongly vertic soils has precluded the transformation of many catchments to crop cultivation, thus allowing the retention of ecological linkages and processes between wetlands and surrounding grasslands.

Through their physical characteristics, many wetlands have been identified to play an important role in the trapping of sediments, as well as phosphates, nitrates as well as toxicants. Certain of the wetlands in the study area are surrounded by areas of active crop cultivation and planted pasture (especially those within sedimentary geology). In certain cases, these fields extend close to, or even into the wetland boundary. These areas of cultivation are likely to be fertilised, and thus may be feeding nitrates and phosphates, as well as silt, into the downstream drainage systems. The downstream wetlands, especially those containing diffuse flow and moribund vegetation are very important in this context.

The wider study area has an industrial component due to the presence of the Majuba Power Station that is indirectly associated with pollutant input into the surrounding environment. The current method of delivering coal to the power station is by truck and a constant stream of truck traffic moves back and forth along the access road to the power station (the Perdekop Road that links to the R35 Morgenzon Road). At the point at which trucks turn off the Perdekop Road onto the Majuba access road, large amounts of coal dust were observed adjacent to the road. A seepage wetland running parallel to the road was noted to be blackened with coal dust. The wetland provides a critical role in trapping this coal dust (a potential pollutant and environmental hazard) that takes the form of sediment, and ensuring that it does not get transported into the downstream drainage system.

Similarly white ‗precipitate' was noted in certain of the wetlands at the upper end of the Palmietspruit Sub-catchment. These parts of the study area are close to the Ash Dam associated with the Power Station. The presence of the precipitate in wetlands becomes much more prominent the closer one gets to the Ash Dam, and it is thought that this substance originates from ash that is blown off the Majuba ash dam, and which is deposited into the adjacent environs. On a number of windy days in the study area, ash was observed to be blowing off the ash dam. It is thought that this material then gets washed into the wetlands (low points in the landscape) where it collects as precipitate. If the ash dam is indeed the source of this material, then the wetlands in this part of the study area are performing a critical role in trapping some of this material close to its source. The farm dams in the wetlands in this area are likely to be crucial in trapping this material.

Most of the wetland reaches were listed as being in a largely natural condition, with the categories of ‗natural / unmodified' or ‗largely natural' being assigned to most of the reaches. This is due in a large part to the land use-related factors listed above. This is an important factor that needs to be taken into account in assigning areas of environmental sensitivity to the study area. This has implications for the overall assessment of wetland loss in the context of the sub-catchments. Due to the nature of land use and the low human footprint in the study area, it has been assumed that there has been a relatively low level of wetland and wetland habitat loss in the sub-catchments of the study area.

Problem areas in wetlands typically remain relatively localised and large parts of many of the study area's wetlands remain highly intact. This status quo needs to be taken into account in the planning of proposed UCG-related mining activities in the study area.

Photograph 14: White precipitate that has gathered on wetland vegetation in the study area

6.5.4 Wetland Prioritisation and Sensitivity

The wetland reaches in the study area have been subjected to a prioritisation exercise in order to assign a level of sensitivity to respective wetland reaches. The prioritisation / sensitivity assessment has taken into account the following factors:

- Level of Wetland Functionality;
- Wetland State;
- Presence / Absence of important biodiversity features;
- Wetland HGM being a rare type (in the context of the study area); and
- Geology underlying the wetland.

In terms of how important biodiversity features were characterised, the following characteristics were deemed to be important biodiversity features:

- Wetland / aquatic Red Data Species present;
- Habitat suitable for Red Data Species;
- Charismatic species recorded or habitat suitable for charismatic wetland species (e.g. Marsh Owls); and
- Completely natural catchment of the wetland reach.

Four categories of sensitivity have been assigned:

- Very High;
- High;
- Moderately High; and
- Moderate.

It should be noted that all wetlands should be regarded as being sensitive areas / components of the study area. The classification of wetland reaches into differing classes of sensitivity has been undertaken in order to indicate those wetlands that should be offered maximum protection, and which should be avoided when aligning linear infrastructure such as powerlines, roads and pipelines.

The sensitivity classes have been assigned based on the following criteria.

Table 36: Criteria used to assign wetland reach sensitivity classes

Wetland Sensitivity Class	Parameter								
	Functionality		State		NB Biodiversity Features		Wetland HGM Type		Underlying Geology
Very High	High	AND	Natural	AND	Present				
High	High	OR	Natural	OR	Present	OR	Pan or Floodplain	ON	Sedimentary / Dolerite*
Moderately High	High	OR	Natural	AND	Absent		ON		Dolerite
Moderate	All Remaining Reaches								

** Note when important biodiversity features are present on wetlands underlain by dolerite geology, the reach is placed in the „high" sensitivity category.*

The highest class of sensitivity reflects those reaches in the study area where the reach displays a high degree of sensitivity, a natural state and displays important biodiversity features.

In the next two (2) classes down, a high degree of functioning, a natural state or important biodiversity features need to be present; in the ‗high' sensitivity class the wetland reach can also be a pan or floodplain and must be located on sedimentary geology (shale or sandstone). In the ‗moderately high' sensitivity class reaches displaying one of the highest ratings in the three (3) categories of state, functionality and biodiversity features must be located on dolerite.

The highest ratings for wetland functionality, state and presence of important biodiversity features have been used as the three primary categorisation factors as wetlands displaying these characteristics would stand to be most affected if subjected to impacts associated with the proposed development.

The two (2) HGM types of floodplains and pan / depression wetlands[30] have been included as a qualifying characteristic for the class of high sensitivity as these are the most uncommon HGM type in the context of the study area, and were found to be typically associated with high levels of biodiversity and important ecosystem services.

Underlying geology has been used as the characteristic to divide wetland reaches that qualify for either the ‗high' or moderately high sensitivity class as wetlands located on sedimentary geology were typically found to have physical characteristics (such as an extensive width and flat terrain) that were associated with a greater degree and number of ecosystem services.

Wetlands in the lowest class of sensitivity will not display any high-rating criteria, and are typically the wetlands that have been most affected by pressures, as reflected by their lower classes of wetland state (largely modified or moderately modified).

[30] *Note that there are no pan / depression wetlands found in the revised greater study area.*

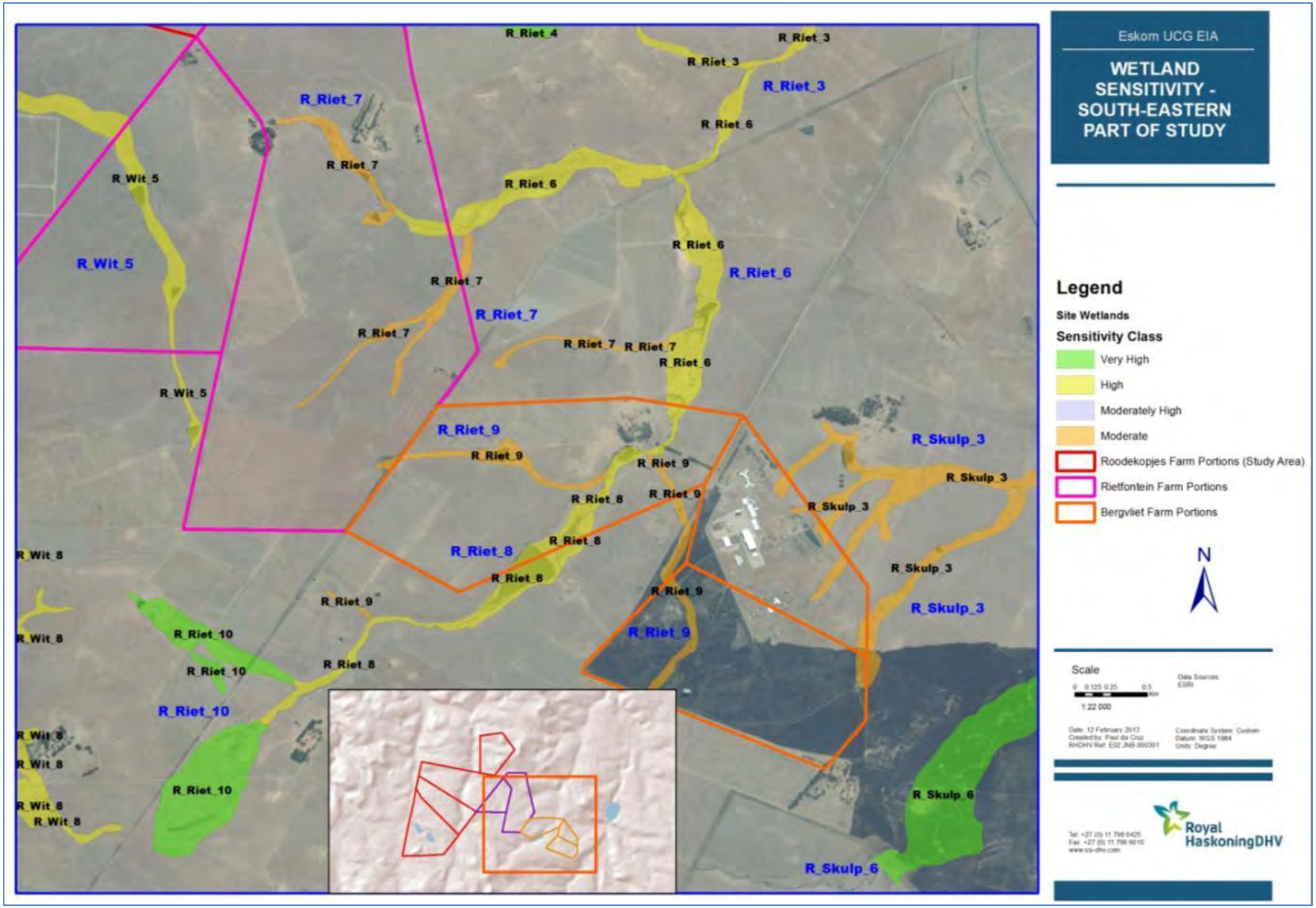


Figure 41: Wetland Sensitivity – south-eastern part of the study area

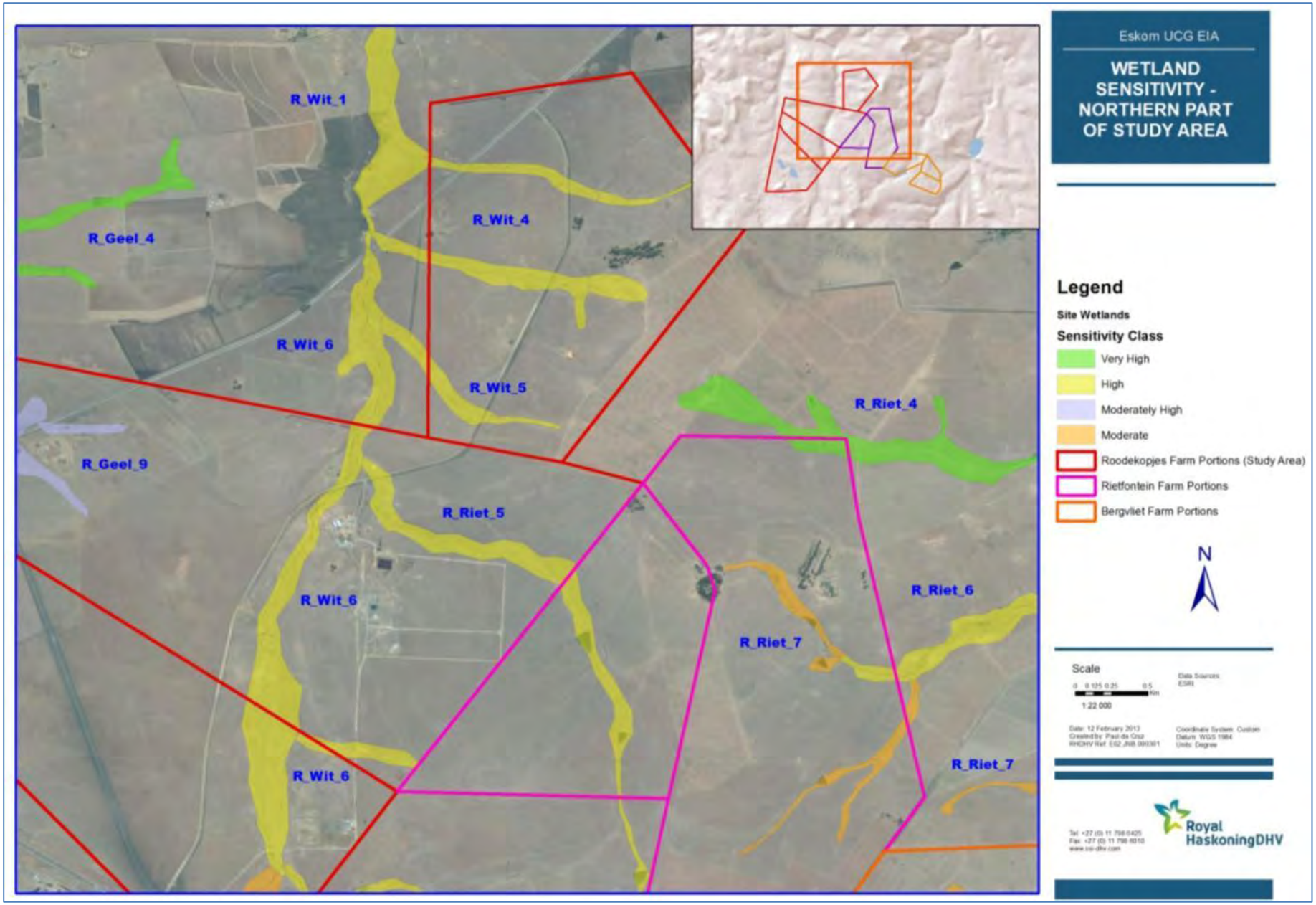


Figure 42: Wetland Sensitivity – northern part of the study area

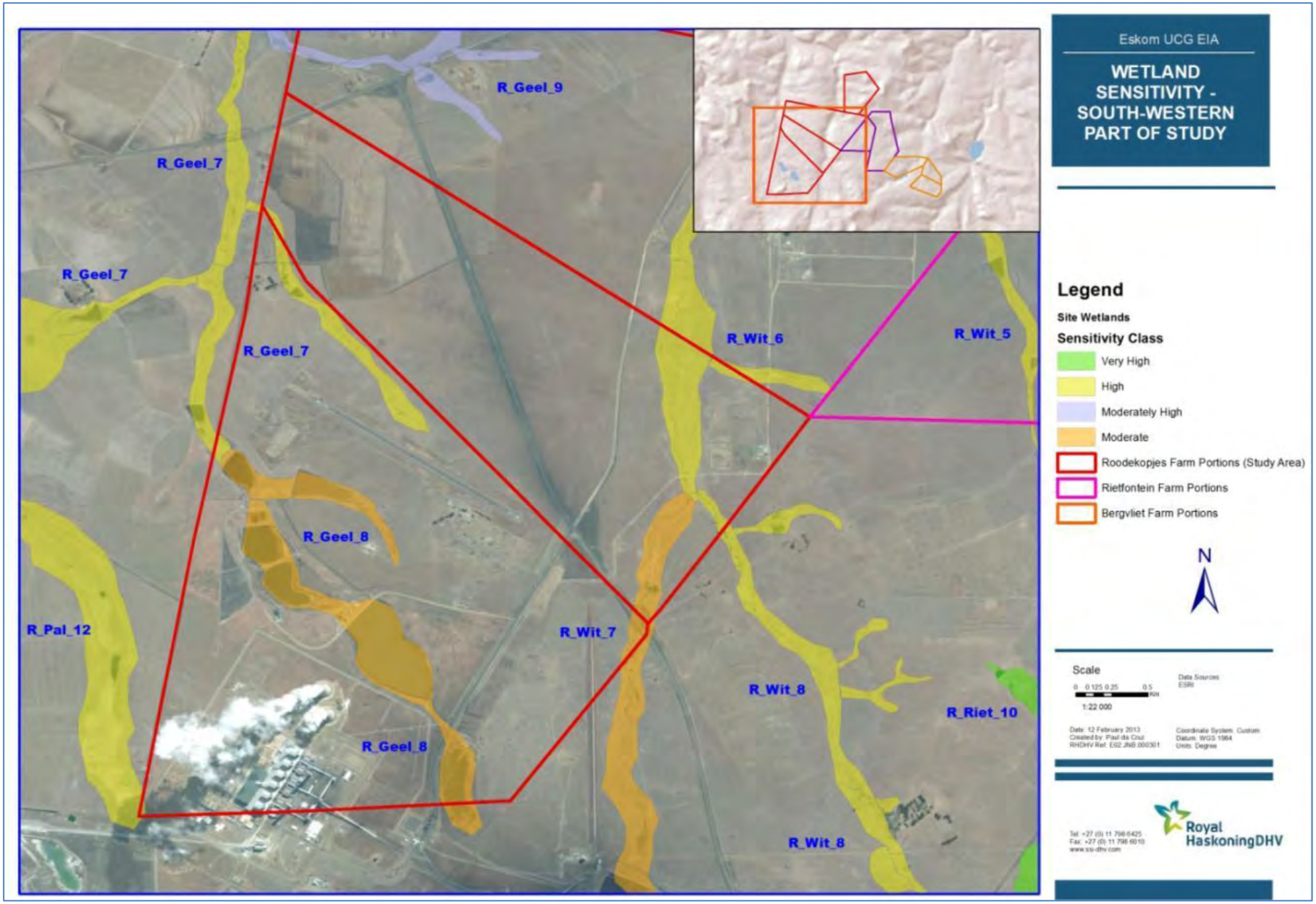


Figure 43: Wetland Sensitivity – south-western part of the study area

6.5.5 Potential Subsidence Impacts

One of the most significant impacts potentially associated with the proposed UCG process is subsidence. Subsidence could occur as a result of the gasification of the coal seam that lies deep underground. Subsidence occurs as a result of the gasification of this seam, with the above strata ‗collapsing' into the space left by the coal seam. Note that the potential for subsidence is still under investigation and forms part of the outcomes of the research investigation outputs of the Pilot Plant Phase 1.

Subsidence could potentially affect wetlands in a number of ways. Firstly surface water flow inputs could be affected. As described above, once the predominantly vertic soils become saturated, they tend to become highly impermeable, and thus most rainfall falling in an area tends to become surface run-off. Thus in the summer months, the predominant surface water input into most of the wetlands from the area (apart from the flow emanating from the upstream part of the wetland) is likely to be from surface run-off from the immediate catchment. Subsidence could have a critical impact on this dynamic. Information provided by the proponent suggests that up to 0.75 m of subsidence could occur. Depending on the spatial extent of the area being undermined in relation to the wetland (i.e. if it underlay the wetland or if wetland areas were excluded from being mined) this could thus potentially result in part of the outer catchment of the wetland subsiding to a level below the ground level of the wetland boundary, or below the ground level of a part of the catchment. This subsidence would presumably form a distinct level difference akin to a micro-escarpment or gulley sidewall. The creation of this level difference would be likely to prevent all above-ground flow from the catchment from flowing into the wetland and any area formerly downslope of the area of subsidence. The level difference could erode back towards the wetland over time if erodible material was exposed (i.e. soils rather than bedrock). This erosion face could erode back into the wetland over time, depending on the composition of the underlying strata that is progressively exposed.

Secondly the subsidence may affect groundwater inputs into wetlands. As described above, groundwater discharge is a critically important feature of the hydrology and associated functionality of many of the wetlands in the study area, particularly those valleyhead seep wetlands that are situated in dolerite geology. Owing to the nature of dolerite, groundwater discharge to the surface is likely to be as a result of fracturing of dolerite bedrock, with flow paths being likely to occur along these fracture lines. Groundwater discharge may occur where the interface of different strata meets the ground surface. The hydrogeological report for the study area states that groundwater flows are likely to mimic topography, with groundwater piezometric levels becoming shallower and shallower (i.e. the groundwater level getting closer and closer to the surface) as one moves towards the valley bottom. In this context subsidence could disrupt / alter these groundwater flow inputs into the wetlands. Subsidence would presumably affect the entire stratigraphical profile, and could possibly alter / disrupt physical fractures along which groundwater would move. This could result in the re-directing of flow paths so that groundwater discharge no longer occurs into the wetland. If groundwater discharge was to no longer occur in wetlands, this would be likely to have a significant impact on the hydrology of the area and a concomitant impact on wetland ecology and wetland functioning and state.

As described above, during low flow periods (i.e. winter) rivers in the area appear to be fed exclusively by base flow (groundwater-fed flow). This baseflow is responsible for the perennial nature of the rivers in the area. The hydro-period of many wetlands in the study area would be altered if groundwater inflow was to be removed as a hydrological input into these wetlands. Under this scenario many wetlands would become much drier, resulting in a change in vegetation composition and loss of flora species that depend on the wetland being saturated for relatively long periods. This would have a resultant impact on the fauna in that wetland and may have further

knock-on impacts on wetland functioning such as the direct provision of water for domestic use, and in particular on cattle, as critical sources or water and grazing would be lost.

It is very difficult to accurately predict at the level of an individual level how subsidence may affect the input of groundwater into the wetland. The level of impact associated with subsidence on wetlands in the study area would depend on a number of factors. In respect of groundwater inputs into a wetland, groundwater flow patterns would need to be modelled to be well-understood. More detailed catchment-level modelling of groundwater flows would be required to be undertaken in order to accurately understand how groundwater inputs to wetlands may be retarded at the level of each wetland and its catchment.

The area of ground that is undermined is a significant factor in terms of how both sub-surface and surface flows into the wetland area affected. If the catchment of an entire wetland unit were to be undermined, then the potential impact on surface flows would be likely to be less than if only a portion of the outer catchment were to be undermined (i.e. the outer portion of a catchment beyond the buffer of the wetland as specified above). This would presumably preclude the creation of an artificial level difference where part of the outer catchment would be lower than the reminder of the catchment and wetland itself. The potential impacts on groundwater inputs would be less clear cut, but as groundwater flows are expected to mimic topography, undermining an entire wetland unit catchment would presumably allow this situation to be maintained. Undermining part of a wetland catchment could have potentially significant impacts on hydrological inputs to wetlands as groundwater flow paths could be disrupted and prevented from reaching their current points of discharge.

6.5.5.1 Implications for development

The parcels of land for the proposed irrigation as indicated in the Management Plan for Irrigation are located very close to a number of valleyhead seep wetlands that are located near the boundary of the Skulpspruit and Witbankspruit respectively. All of these are valleyhead seeps, although they all become valley bottom wetlands lower down in the reach. Importantly three of the four wetland systems that rise in close proximity to the proposed site of the irrigation were identified as being of high sensitivity (two – the valleyhead seepage wetlands in the Witbankspruit catchment – R_Wit_4) or very high sensitivity (R_Riet_4 in the Skulpspruit catchment). As detailed above, this sensitivity has been assigned based on a number of factors, including the wetland state, functionality and biodiversity features.

For the two wetlands in the Witbankspruit catchment the high level of sensitivity was based on a largely natural state of the wetlands and the presence of potential habitat for Red Data species. In the case of the valleyhead seepage and associated un-channelled valley bottom wetland (R_Riet_4) in the Skulpspruit catchment, the wetland was assigned a very high sensitivity due to a natural / unmodified state, a high degree of functionality, and biodiversity reasons including habitat suitable for Red Data-listed species and ecological linkages between wetland and associated natural catchment. This part of the wetland reach in the uppermost part of the catchment is highly natural, and is unusual in the context of the study area in that it takes the form of an un-channelled valley bottom in a flat ‗bowl' in sandstone geology, unlike most of the other valley bottoms in the area that are more incised and more channelized. The vegetation in the wetland is moribund and diffuse flow occurs in the wetland. Importantly the wetland's catchment is highly natural and from the field observation contained a high floristic diversity. The underlying geology of sandstone would suggest that a greater risk of surface-groundwater interaction within this wetland as opposed to the wetlands on dolerite would exist.

The presence of these high, and in particular the very high sensitivity wetlands and their associated buffers has important implications for the proposed irrigation of the area with effluent. The buffer recommendation for high sensitivity wetlands is 100 m beyond the boundary of the wetland, and for very high sensitivity wetlands the entire catchment of the portion of the wetland reach should be buffered.

6.5.6 Impacts associated with linear infrastructure

Part of the associated infrastructure consists of linear infrastructure, including roads and pipelines. All of these types of linear infrastructure could potentially be associated with impacts on wetlands. The generic impacts associated with each type of linear infrastructure are explored in the document at hand, and has been assessed.

6.5.6.1 Impacts relating to pipelines

It is understood that all pipelines are likely to be above-ground structures. This entails that the pipeline would be founded on support structures such as pilings / pillars which would have their foundations in the ground. The pipeline would have a permanent footprint where it crosses wetlands, but this footprint would be limited to the area around the support structures.

The pipeline would thus have a physical impact on wetlands, but the footprint would be limited. The impact is due to the footings which have a different erodibility to the surrounding river bed and bank areas and thus leads to changes in the watercourse‘s flow patterns and bed morphology.

Photograph 15: Existing pipeline crossing the Witbankspruit near the demonstration plant

Pipeline-related impacts could result in both the construction and operational phases. In the construction phase, wetlands would likely need to be accessed by construction crews and machinery to lay foundations for the support structures, and to further construct the pipeline through the wetland. Due to the need to access the wetland with heavy machinery, the most important potential impact of the pipelines (proposed and existing) on wetlands relates to the disturbance of wetland soils and vegetation. Heavy machinery could compact soils (especially if wet and thus more ‗plastic‘) and destroy vegetation through uprooting. This is a particular risk in the more inundated wetlands where soils are likely to be more vulnerable to compaction and where more sensitive wetland vegetation is located.

Water is an erosive force, and the exposed soils could be eroded, especially in the permanently wet parts of the wetlands where above ground or underground flow / seepage of water through the wetland would naturally occur. If the flow of water and seepage out of the wetland soils was not controlled, this could initiate a ‗*nick point*‘ which may lead to development of gulley (donga) erosion into the upstream part of the wetland. Any eroded

material would be deposited in the downstream portion, potentially causing sedimentation in that part of the wetland which may smother the existing vegetation, and leading to further impacts on this part of the wetland.

Biota in the wetland may be disturbed, but this is likely to be a disturbance that is limited to the length of time of construction through the wetland. Biota is likely to return to the wetland, provided that the habitat integrity remains in a similar state to the pre-construction state.

Other potential construction period-related impacts potentially associated with the construction of pipelines through wetlands are:

- The pollution of water within the wetland, through construction activities; and
- The incorrect re-instatement of wetland vegetation that may result in the exposing and erosion of wetland soils.

In an operational context, the limited physical footprint of the pipeline through the wetland should minimise the impacts associated with the pipeline. The spacing of support structures should allow the surface hydrology of the wetland to be maintained. This factor would also allow the free movement of biota along the wetland.

Impacts may arise if construction-related impacts are not properly mitigated; i.e. if vegetation that is disturbed is poorly rehabilitated, this may result in exposing of soils and may lead to the development of headcut erosion.

6.5.7 Other Project-related Impacts

The erection and then operation of mining infrastructure and other associated infrastructure such as water treatment plants could be associated with other generic construction-related impacts on wetlands / rivers that are detailed below. The most important of these potential impacts relate to:

- A lack of / poor stormwater controls being put in place on the construction site. This may result in the creation of run-off containing pollutants such as cement and oils being transported by stormwater run-off into nearby drainage systems.
- The dumping of construction material, including fill or excavated material into, or close to surface water features that may then be washed into these features.
- Spills of hazardous materials, especially oils and other hydrocarbons that may be washed into, or infiltrate nearby surface water features.
- The conducting of certain construction-related activities (such as cement batching) too close to surface water features or without the implementation of certain controls that may lead to the direct or indirect pollution of the surface water feature.
- The lack of provision of ablutions that may lead to the conducting of ‗informal ablutions' within or close to a surface water feature that may lead to its pollution by faecal contaminants.
- The interaction of untrained construction workers with wetlands and water resources, which could result in the washing if equipment in rivers, for example.

Most of these and other potential construction-related impacts can be minimised or adequately mitigated by controlling construction activities on the basis of an appropriately designed Environmental Management Programme (EMPr). As mentioned above, the relative proximity of the construction activities to surface water features is an important factor in the degree of risk of these construction-related impacts occurring.

6.5.8 *Impacts of the UCG process on shallow groundwater*

In addition to the impacts discussed above the UCG mining process could potentially be associated with a number of indirect impacts on the water cycle, and thus on wetlands and drainage lines. Should groundwater become polluted through the process, this could result in polluted water being discharged via seepage areas wetlands and downstream rivers.

6.5.9 *Impacts related to the removal of cattle*

It is understood that due to health and safety concerns, all people and livestock would be removed from the areas in which UCG mining would be taking place for the operational life-time of the respective mining area.

This would entail that the livestock rearing would stop for this period of time. The removal of all livestock from the wetlands and catchments of the wetlands for this period of time is likely to constitute a positive impact on the wetlands on the site.

The removal of this factor for an extended period of time will give the wetlands that have been subject to cattle-related impacts a chance to naturally recover, and no further degradation would be likely to occur. This factor would be even more beneficial if during this time certain of the problem areas in the wetlands on the site (especially erosion-related impacts) were able to be rehabilitated.

Should environmental offsets for impacts related to the proposed development be required, the rehabilitation of erosion-related problems in wetlands would be an excellent way to achieve this objective. Rehabilitation efforts would be likely to be much more successful in this period without the presence of cattle compared to if cattle were still present.

Note that the removal of the cattle is recommended as it will lead to an improvement of the natural vegetation. It however is not mandatory, but remains a recommendation.

6.5.10 *Recommendations*

Different buffers are recommended to be maintained beyond the wetland boundaries according to the sensitivity of the wetland reach:

Table 37: Recommended buffers for differing classes of wetland sensitivity

Class of Wetland Sensitivity	Buffer
Very High	The entire catchment of the reach should be included as part of the buffer, i.e. no development, including the alignment of linear infrastructure, irrigation of land with effluent, or undermining of the catchment should be allowed within the catchment of the reach
High	100 m buffer beyond the boundaries of the wetland i.e. no development, including the alignment of linear infrastructure where possible, irrigation of land with effluent, or undermining of the catchment should be allowed within the buffer zone
Moderately High	50 m buffer beyond the boundaries of the wetland i.e. no development, including the alignment of linear infrastructure where possible, irrigation of land with effluent, or undermining of the catchment should be allowed within the buffer zone

The greater buffer width around ‗very high' or ‗high' sensitivity wetlands has been recommended in order to offer greater protection to these most sensitive wetlands in terms of providing a greater distance between proposed

infrastructure and the wetland. It also allows ecosystem linkages and processes between the wetland and surrounding grasslands to be maintained, with the retention of a natural gradient between the wetland and catchment being one of the primary reasons that many reaches were assigned a high degree of sensitivity. The buffering of the catchment from development in these wetlands would be very important in the context of the potential subsidence of ground due to undermining that could have a significant impact on the wetland and its hydrology.

The following exclusions must apply to the buffer areas:

- No UCG mining activities should occur within any of the buffer areas – i.e. no undermining should occur in the buffer.
- No irrigation of land with effluent should occur within the buffer.
- The construction footprint should not affect the buffer zone in any way.
- No storage areas for hazardous materials (such as fuel), parking areas for vehicles or any temporary toilets should be located within a 50 m zone beyond the buffer.

The mitigation measures proposed in the Wetland Report (**Appendix H**) and EMPr should be enforced in the construction and operation of the roads through wetlands in the study area.

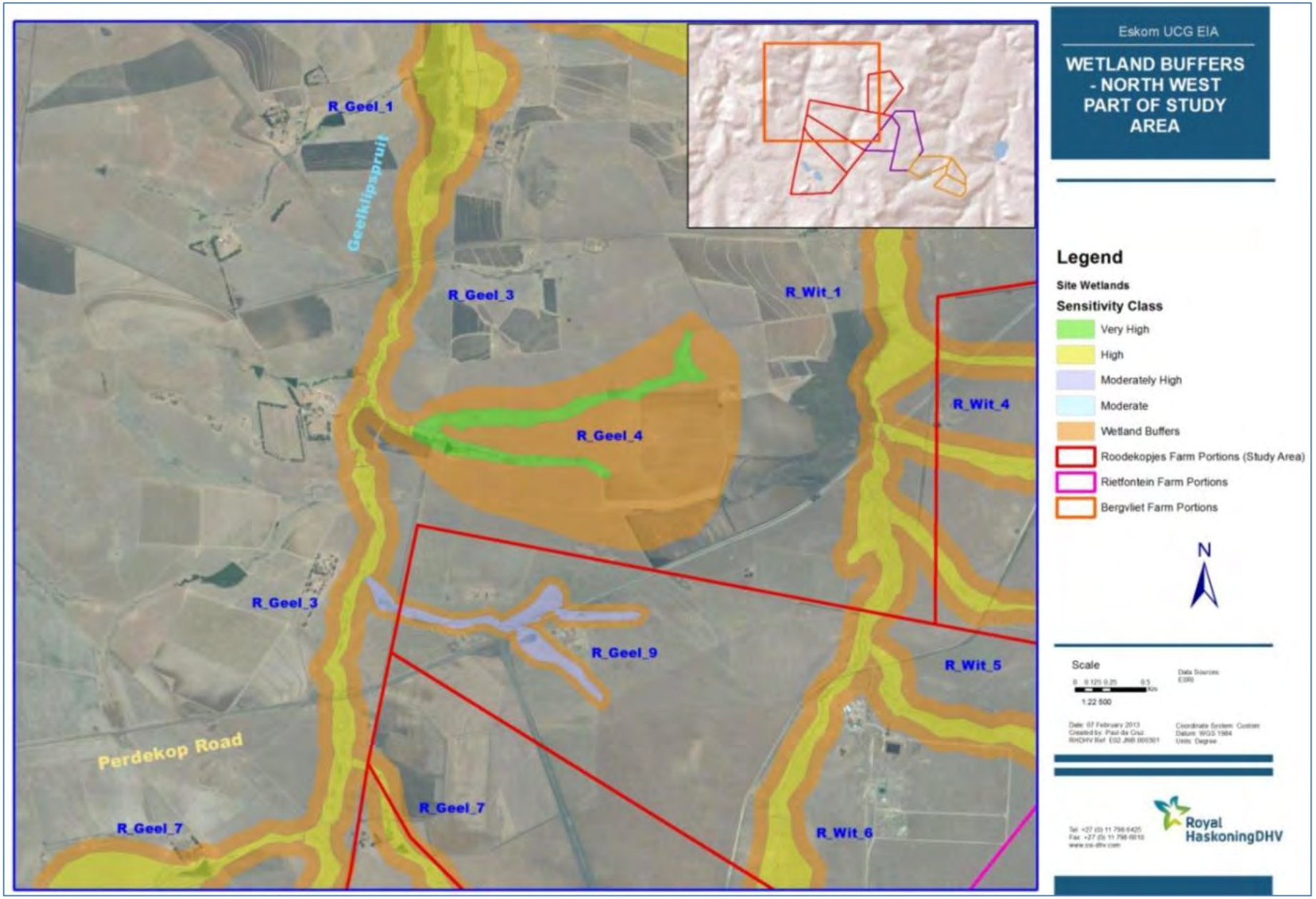


Figure 44: Wetlands and associated buffers – north-west part of the study area

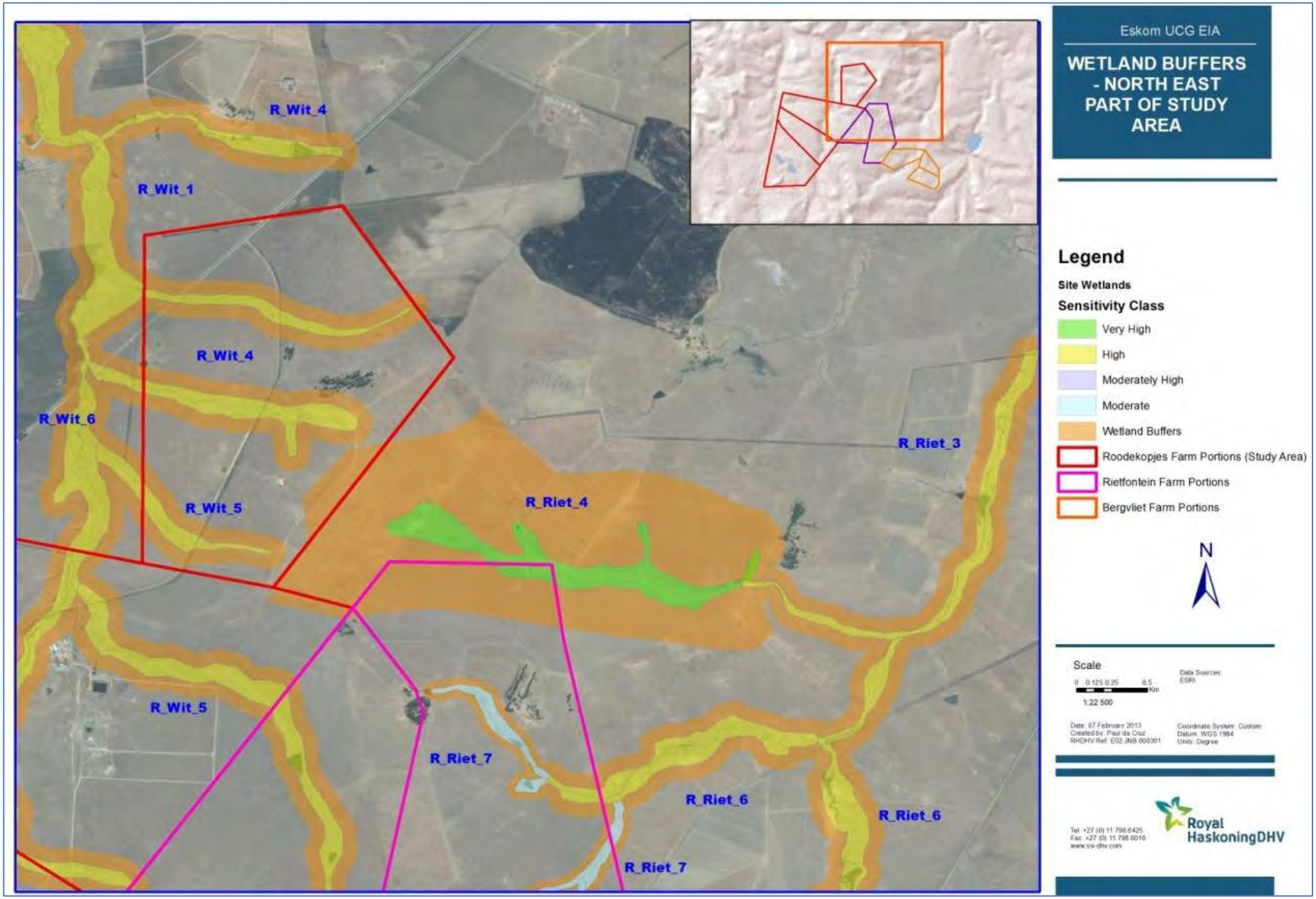


Figure 45: Wetlands and associated buffers – north-east part of the study area

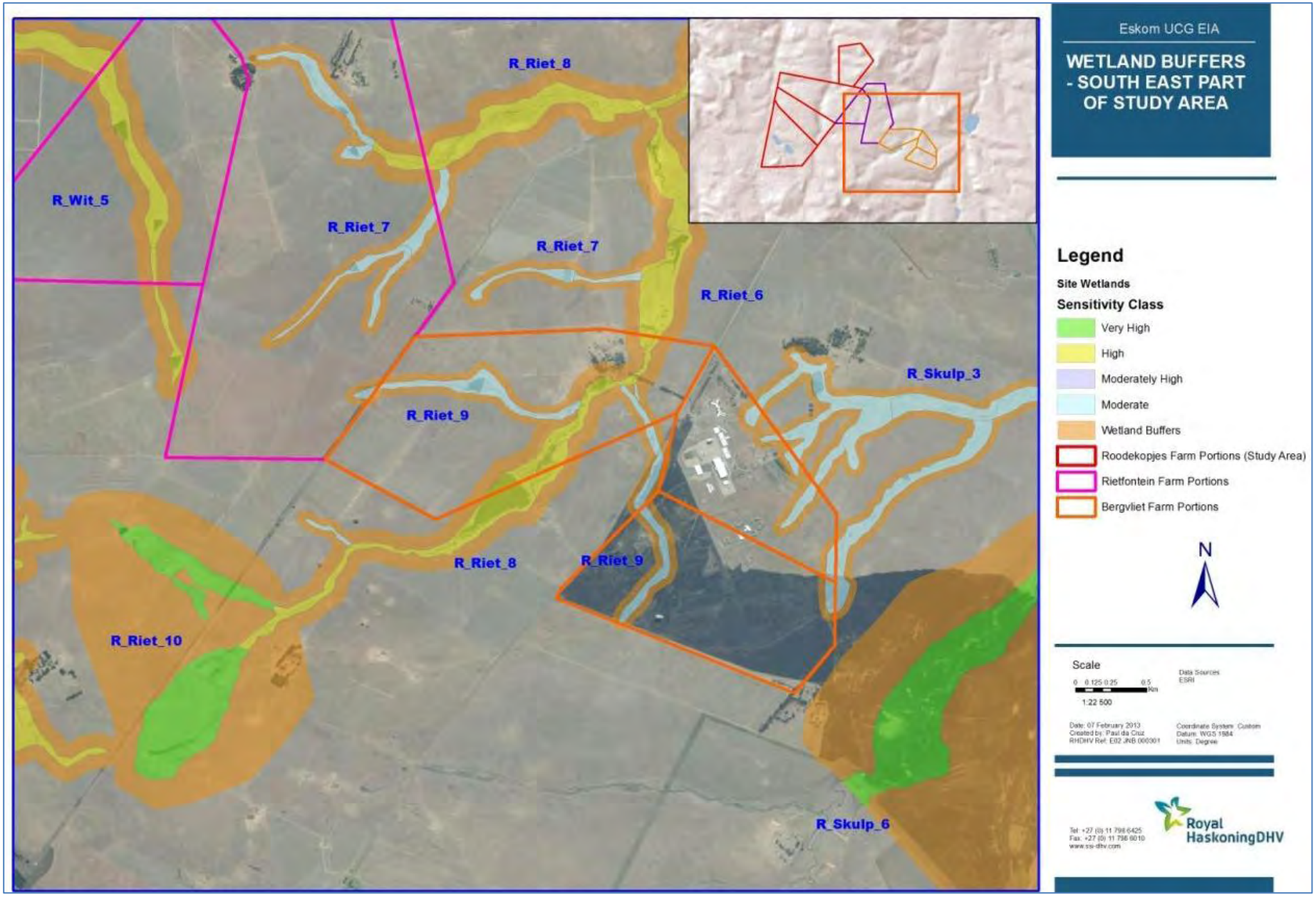


Figure 46: Wetlands and associated buffers – south-east part of the study area

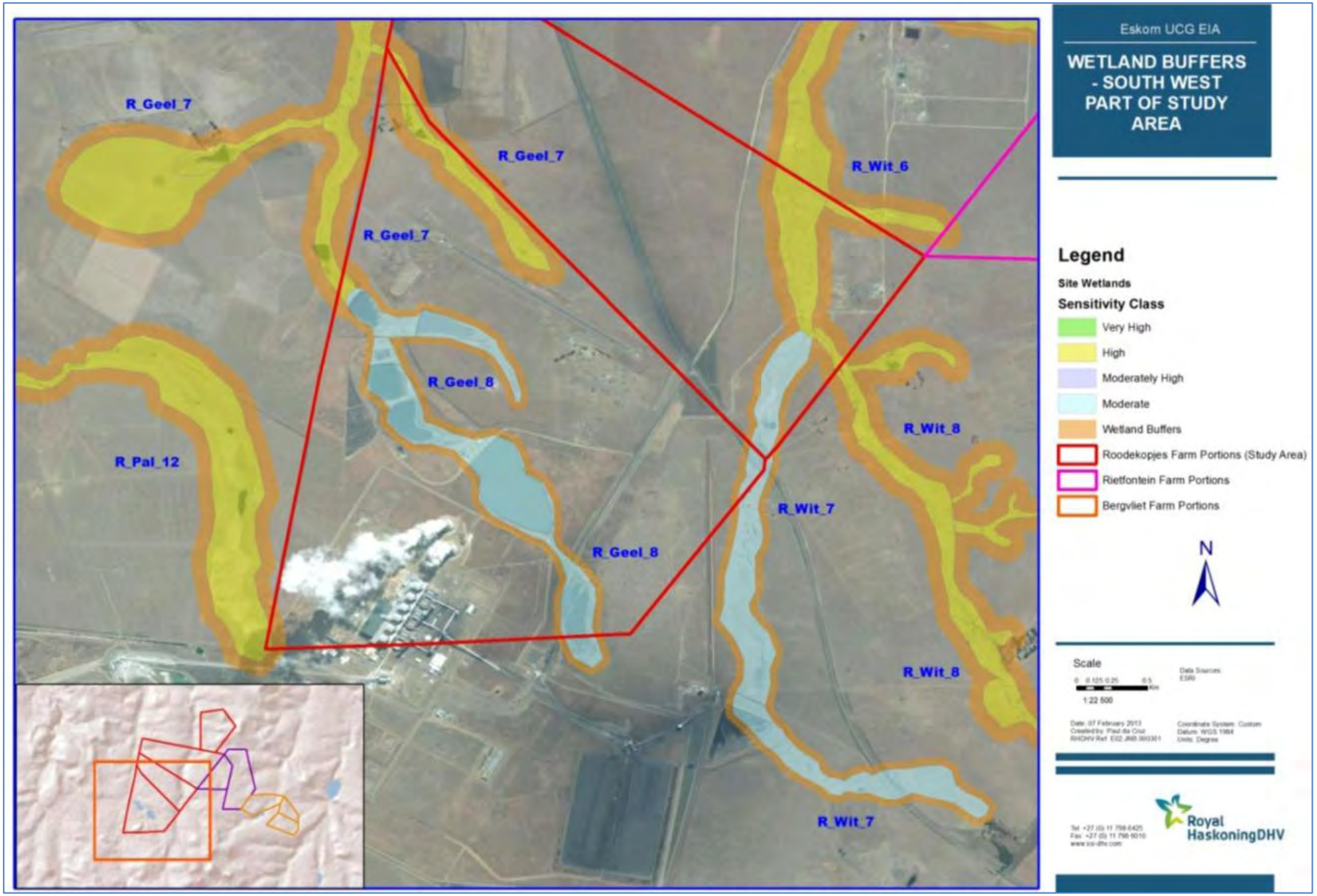


Figure 47: Wetlands and associated buffers – south-west part of the study area

6.6 Soils and Agricultural Potential

The interpretation of the land use, land capability and reconnaissance soil survey results yielded a number of aspects that are of importance to project.

6.6.1 Crop Production

The soils found on the site are generally of medium to low agricultural potential (dryland and irrigated cropping) due to a number of reasons. These are:

- The soils are generally shallow with thin soil profiles overlying weathering rock or distinctly higher clay content sub-soils.
- The soils on the site are generally poorly drained with poor internal drainage that hampers aeration. These conditions are problematic during high rainfall years.
- Due to the high clay content and shallow nature of most of the soils they tend to hold limited quantities of water. This is a restricting factor during low rainfall years.
- Due to the abundance of rocks as well as the presence of strongly developed structure in most of the soils they are difficult to manage and tilling is very challenging.
- Due to the poor drainage as well as the presence of swelling clay throughout the landscape the soils are very susceptible to erosion.

6.6.2 Soil Erosion and Degradation

The soils on the site are very susceptible to erosion. The susceptibility stems from the presence of swelling clays. These clays lead to low water infiltration rates into the soil meaning that surface run-off is a regular occurrence during rainfall events. Once the soil is exposed (through the removal of the vegetation cover or other disturbances) the swelling nature of the clays contributes to dispersive properties of the soil. Under these conditions there is no cohesion between soil particles and they are therefore readily dislodged and transported by water. This aspect is a very real threat to the stability of most of the soils on the site, especially those in drainage depressions and lines. As such eroded stream channels are observed throughout the site.

6.6.3 Derived Soil Quality Parameters

Table 38 provides the estimated soil quality parameters for the site as well as their status. It is important to note that the natural fertility of the high potential soils is considered to be low. These soils only attain their true potential after adequate fertilization.

Table 38: Estimated soil quality parameters for the various soil groups

Soil Group	Natural Fertility	Erodibility	Dry-land crop production potential	Irrigation potential
Shallow and rocky soils on convex topography	High	Medium	Low	Low
Variable depth structured soils in flat terrain outside drainage depressions	Medium to High	Medium	Low to Medium	Low
Structured and swelling soils in drainage depressions (concave topography)	High	Medium to High	Low	Very Low

6.6.4 Agricultural Potential

The agricultural potential of the soils on the farm Roodekopjes 67HS is considered to be low in terms of crop production but medium to high in terms of extensive grazing. This is mainly due to the shallow and rocky nature of the soils as well as their swelling properties.

Post-mining agricultural potential depends to a very large extent on the rehabilitation efforts by the Eskom. The baseline agricultural potential is low though meaning that at best the post-mining agricultural potential will also be low.

6.6.5 Potential Impacts

In terms of soils, impacts are described as different forms of soil degradation.

Soil degradation can be divided into the following classes and subclasses:

- Physical degradation:
  - Compaction;
  - Surface crusting;
  - Erosion; and
  - Structural degradation / hardsetting.
- Chemical degradation:
  - Eutrophication:
    - Nitrogen; and
    - Phosphorus.
  - Soil organic carbon losses or alteration;
  - Trace element and heavy metal pollution;
  - Acidification;
  - Salinisation and sodification; and
  - Nutrient mining.
- Biological degradation:
  - Soil microbial activity decrease / increase; and
  - Soil borne human, animal and plant pathogens.
- Soil quality deterioration (compound effects);
- Soil health deterioration; and
- Soil destruction.

Table 39: List of activities and their associated forms of soil degradation

Activity	Form of Degradation
Construction	
Drilling of holes and associated vehicle movement	Physical degradation (surface)
Construction of manifold system and pipes	Physical degradation (surface)
Construction of temporary buildings and other infrastructure	Physical degradation (compound)
Vehicle operation on site	Physical and chemical degradation (hydrocarbon spills)
Dust generation	Physical degradation
Dust suppression	Chemical degradation
Operations	
Operation and gas extraction	No additional degradation
Vehicle operation on site	Physical and chemical degradation (hydrocarbon spills)
Dust generation	Physical degradation
Dust suppression	Chemical degradation
Decommissioning	
Capping and sealing of boreholes	No additional degradation
Removal of manifold system and pipes	No additional degradation
Rehabilitation of access roads and drill areas	No additional degradation
Vehicle operation on site	Physical and chemical degradation (hydrocarbon spills)
Dust generation	Physical degradation
Dust suppression	Chemical degradation

6.6.6 Recommendations

The soils found on the site of the proposed Eskom UCG project are mainly restricted to structured soils of shallow to variable depth.

These soils can be divided into three (3) main categories namely:

a. Shallow and rocky soils on convex topography;
b. Variable depth structured soils in flat terrain outside drainage depressions; and
c. Structured and swelling soils in drainage depressions (concave topography).

The soils found on the site pose a challenge in terms of wetland delineation due to their specific chemical and mineralogical composition. The main land-use is grassland used for extensive grazing. A limited area is used for dryland agriculture and the agricultural potential of these areas is relatively low due to the dominance of structured and limited depth soils.

The proposed mining process will impact large areas but soil conditions will not be altered drastically due to the characteristics of the soils. In the case of swelling soils their self-mulching nature will lead to the disappearance of small disturbances over time. It is anticipated that the grazing potential of the impacted areas will be negatively impacted but it is possible that this potential will improve with time as the signs of impacts fade.

The major risk to the soils is erosion due to the removal of the vegetation cover. All mining construction activities should take into account the erodibility of the soils and make provision for its prevention.

6.7 Biodiversity

6.7.1 Flora

A total of 185 plant species were recorded during the various site investigations (refer to the Biodiversity Report – **Appendix K**). The regional setting within the Grassland Biome dictates the physiognomic dominance of the herbaceous component with 100 (one hundred) forb species and 41 (forty-one) grass species. Trees are present as low shrubs or as stands of exotics. The species composition of untransformed grasslands is regarded representative of the principal regional vegetation type. A total of 47 (forty-seven) plant families were recorded in the study area, dominated by the Poaceae and Asteraceae families.

SANBI records for the region and survey results indicate the presence of eight (8) flora species of conservation importance, none of which are threatened:

- *Acalypha caperonioides* var. *caperonioides* (Data Deficient);
- *Boophone disticha* (Declining);
- *Crinum bulbispermum* (Declining);
- *Eucomis autumnalis* (Declining);
- *Ilex mitis* var. *mitis* (Declining);
- *Khadia alticola* (Rare);
- *Lobelia erinus* (Near threatened); and
- *Nerine platypetala* (Insufficiently known).

The following provincially protected species were recorded within the study area (Mpumalanga Nature Conservation Act No. 10 of 1998):

- *Boophone disticha*;
- *Crinum bulbispermum*; and
- *Gladiolus* species.

The photo analysis and site investigations revealed the presence of the following floristic habitat types:

- **Agricultural Areas (18.2%, Low floristic sensitivity)**

Cultivation represents the major land transformation activity in the region, resulting in a mosaical pattern of agricultural fields within a natural grassland environment. These areas include lands that are either currently actively cultivated for crops, or fallow fields where agricultural activities has ceased some time ago, but the vegetation still reflects the impact of transformation. No Red Data plant species were recorded within these parts. The likelihood of encountering Red Data plant species within these parts is low, mainly as a result of habitat transformation.

- **Degraded Grassland Habitat (3.3%, Low floristic sensitivity)**

Vegetation of these parts is frequently impacted by mowing activities that result in a significantly altered species composition while the physiognomy reflects that of cultivated pastures. The species *Eragrostis curvula*, *E. chloromelas*, *Hyparrhenia hirta* and *Hyperthelia dissolute* are usually particularly dominant and is also a good indicator of the secondary climax status that resulted through succession from a historic disturbance, such as over-grazing or recent pastural practices. No conservation important species were recorded within these areas. The likelihood of encountering Red Data plant species within these areas are regarded low as a result of habitat transformation.

- **Exotic Stands (0.3%, Low floristic sensitivity)**

This habitat type comprises all areas where natural vegetation has been replaced by stands of exotic trees, mostly Eucalyptus species. These areas are frequently in proximity to homesteads and were introduced by settlers or subsequent residents to serve as wind- or visual breaks on the open grasslands.

- **Moist Grassland / Grassland Seepages (1.4%, Low floristic sensitivity)**

This vegetation type is generally termed ‗hydromorphic grasslands' or ‗ephemeral moist grasslands' and constitutes grassland that occur in-between terrestrial and aquatic systems, usually situated on terrain type 4 (footslopes) in close vicinity to valley bottoms (drainage lines, streams, rivers). Moist conditions are indicated by the presence of several sedges as well as the grasses *Agrostis eriantha*, *Andropogon huillensis*, *Aristida junciformis*, *Fingerhuthia africana*, *Helictotrichon turgidulum*, *Leersia hexandra* and *Setaria nigrirostris* as well as the forbs *Berkheya carlinopsis*, *Boophone disticha*, *Chironia palustris*, *Crinum bulbispermum*, *Senecio achilleifolius* and *Rumex* species. No Red Listed flora species were observed during the site investigation. Habitat is considered particularly suitable for the presence of conservation important flora species.

- **Natural Grassland Habitat – Amersfoort Variations (61.0%, Low floristic sensitivity) (Dominant vegetation type)**

The natural grassland of the study areas are characterised by a short, low cover of herbaceous species, physiognomically dominated by grasses. The floristic status of these parts is largely determined by the intensity of grazing by cattle and sheep. Areas subjected to lower grazing pressure comprises vegetation with a higher floristic status and species diversity. The species diversity in these parts is more diverse, comprising a high degree of forbs and geophytes in particular, including *Boophone disticha*, *Gladiolus crassifolius*, *Gladiolus* species, *Hypoxis iridifolia*, *H. obtusa* and *H. rigidula*. Areas where high grazing pressure predominate is characterised by a vegetation that exhibits high abundance values of the grasses *Eragrostis plana*, *E. chloromelas*, *Cynodon dactylon* and the forbs *Cirsium vulgare*, *Berkheya carlinopsis*, *Alternanthera pungens* and *Crepis hypochoeridea*. No plant species of conservation importance was recorded within these parts of poor quality grasslands. The likelihood of encountering Red Data plant species within these areas are regarded medium as a result of moderate habitat status; pristine areas are however regarded suitable for the potential presence of Red Data flora species.

- **Transformed Habitat (8.9%, Low floristic sensitivity)**

This habitat type represents areas where historical or recent human activities led to transformation of the natural vegetation. No natural vegetation remains in these areas and the floristic status of these areas is therefore regarded low as a result of the secondary vegetation that characterises this habitat type. The likelihood of encountering Red Data species within these areas are regarded low.

- **Wetland / Riparian Habitat (7.0%, Low floristic sensitivity)**

The floristic status of these areas is regarded high and few impacts, other than high grazing pressure are noted. However, an impact that does affect the status of these areas adversely is damming practices of upstream catchment areas, causing changes in the flow patterns and soil moisture content in downstream areas. Trampling of the topsoil by cattle as well as infestation of the streambed by terrestrial species, imported by means of droppings and physical transportation methods, result in species changes in some areas.

Species that were frequently encountered in these parts include the grasses *Leersia hexandra*, *Brachiaria eruciformis*, *Eragrostis plana*, *Paspalum scrobiculatum*, *P. dilatatum*, *Arundinella nepalensis*, *Fingerhuthia africana*, the hydrophilic species *Cyperus* species, *Typha capensis*, *Oxycarpus* species, *Scirpus* species and the forbs *Polygonum lapathifolia*, *Senecio achilleifolius*, *S. inornatus*, *Oenothera rosea*, *Crinum* species, *Falkia oblonga*, *Denekia capensis*, *Helichrysum aureonitens*, *Haplocarpha lyrata*, *Rumex* species, species and *Eucomis* species. The tree *Salix babylonica* frequently infests the streambanks. Taking the Red Data species

that occur in the region into consideration, these areas are highly suitable for the potential present of these species. No Red Data species were however recorded during the investigation period.

6.7.2 Fauna

- A total of 12 (twelve) butterflies are known from the ¼-degree grid that is sympatric to the study area. Ten species were recorded during the site investigation. No Red Data species are known from the Q-grids of the study area.
- A total of 15 (fifteen) frog species are listed for the study area and no Red Data species are known to occur in the region.
- A total of 17 (seventeen) reptile species are listed for the study area, including the Red Data species Sungazer lizard (*Cordylus giganteus*, VU) which was recorded during the site investigations and are also known to occur in several localities in the region.
- A total of 318 (three hundred and eighteen) bird species are listed for the Q-grids of the study area, including 37 (thirty-seven) Red Data species. Sixty-three species were recorded during the site visit, including five (5) Red Data species; Botha's Lark (EN), Secretarybird (NT), Blue Korhaan (NT), Bald Ibis (VU) and Black Harrier (VU); and a total of 39 (thirty-nine) mammal species are listed for the region, including 10 (ten) Red Data species. Seven (7) mammal species were recorded during the site visit.

The following habitat types were recognised in the study area:

- **Agricultural Areas (Low faunal sensitivity)**

No natural habitat remains in this unit as all vegetation has been removed for agricultural purposes. The faunal diversity of this area is extremely low and comprises common bird and mammal species that are associated with transformed habitat types.

- **Degraded Grassland Habitat (Medium-low faunal sensitivity)**

Species to be expected in the degraded faunal habitat of the study area include Brown-veined White, African Migrant, African Monarch, Cupreous Blue, Broad-bordered Grass Yellow, Citrus Swallowtail, Boettger's Caco, Guttural Toad, Common Egg Eater, Mole Snake, Grey Heron, Cattle Egret, Hadeda Ibis, Egyptian Goose, Swainson's Spurfowl, Common Quail, Crowned Lapwing, Rock Dove, Cape Turtle-Dove, Laughing Dove, Speckled Mousebird, Black-backed Jackal and Natal Multimammate Mouse.

It should be noted that representative parts of this habitat is situated in close proximity to high sensitivity habitat and will therefore perform an important role in terms of connectivity. A medium-low faunal sensitivity is nonetheless attributed, mainly as a result of the absence of any habitat characteristics that are associated with sensitive fauna species.

- **Exotic Stands (Low faunal sensitivity)**

Stands of exotic trees are useful in providing shelter for a select number of fauna species. It is a well-known area of roosting and nesting for species such as Lesser Kestrel (*Falco naumanni*, VU), Amur Falcon (*Falco amurensis*) as well as for a number of terrestrial species. However, these areas are ultimately still considered as transformed and the utilization of these areas is necessary adaptations rather than indications of good faunal habitat. The faunal diversity of this area is extremely low and comprises some bird species that are frequently associated with transformed habitat types.

- **Moist Grassland / Grassland Seepages (High faunal sensitivity)**

This habitat type is located adjacent to the riparian zones in the north-eastern corner of the study area. It is well-connected to other areas of natural terrestrial grassland as well as riparian habitat. The moist grassland habitat is therefore estimated to have a high faunal sensitivity.

- **Natural Grassland Habitat (Medium-high faunal sensitivity)**

Several Red Data species (Sungazer lizard, Bald Ibis, Secretary bird, Blue Korhaan) were observed in this habitat type, rendering these habitat fragments high in faunal sensitivity.

- **Transformed Habitat (Low faunal sensitivity)**

These parts have low ecological value and biodiversity potential and are consequently considered to have a low faunal sensitivity with regards to the proposed project.

- **Wetland / Riparian Habitat (Low faunal sensitivity)**

The aquatic nature of this unit renders it extremely sensitive in terms of faunal attributes. As a result of the transformation of immediate surrounds (agriculture) the functionality of these parts are fairly low. The conservation of these areas is nonetheless advocated and the connectivity with the nearby Riparian Fringes should be improved by means of basic landscaping.

Habitat types that exhibit high faunal sensitivities are frequently strongly associated with important ecological habitat types such as wetlands, outcrops and pristine grassland habitat types. Red Data species are frequently recorded in these areas and a high likelihood is frequently ascribed to the potential presence of such species. The continued preservation of these habitat types, with particular reference to ensuring a high connectivity, is an important step in conserving the natural and sensitive faunal assemblages of the region.

6.7.3 Ecological Sensitivity

Results of the respective floristic, faunal, wetlands and soils sensitivity analysis were combined to present an overview of the ecological sensitivity of the study area (**Appendix K**). In order to present the reader with an indication of the ecological sensitivity of the respective communities, the highest sensitivity for each ecological unit is selected as being representative of the ecological sensitivity of the specific ecological unit. Results are determined in **Figure 42**.

Table 40: Ecological sensitivity of the study area

Community	Floristic Sensitivity	Faunal Sensitivity	Ecological Sensitivity
Agricultural Fields	Low	Low	**Low**
Degraded Grassland	Low	Medium-low	**Medium-low**
Exotic Stands	Low	Low	**Low**
Moist Grassland	High	High	**High**
Natural Grasslands	Medium	Medium-high	**Medium-high**
Wetland Habitat	High	High	**High**
Transformed Areas	Low	Low	**Low**

Combined results from the floristic and faunal sensitivity analysis indicate the high sensitivity of the areas associated with wetland regimes. The status of these areas is moderately pristine and are therefore considered suitable habitat for a variety of conservation important flora and fauna taxa. Unfortunately these areas are relative small in size and are not well represented in the general region.

A medium-high ecological sensitivity is exhibited by the natural grassland areas of the study area, particularly as a result of the presence of several conservation important taxa and the high suitability of these areas for Red Data species.

The largest extent of the study area exhibits low and medium-low ecological attributes and the proposed activity is not expected to result in significant impacts in these areas.

6.7.4 Potential Impacts

6.7.4.1 Destruction of Threatened Flora Species

This impact is regarded a direct impact as it results in the physical damage or destruction of Red Data or Threatened species or areas that are suitable for these species, representing a significant impact on the biodiversity of a region. Threatened species, in most cases, do not contribute significantly to the biodiversity of an area in terms of sheer numbers as there are generally few of them, but a high ecological value is placed on the presence of such species in an area as they represent an indication of pristine habitat conditions. Conversely, the presence of pristine habitat conditions can frequently be accepted as an indication of the potential presence of species of conservation importance, particularly in moist habitat conditions.

Red Data species are particularly sensitive to changes in their environment, having adapted to a narrow range of specific habitat requirements. Habitat changes, mostly a result of human interferences and activities, are one of the greatest reasons for these species having a threatened status. Surface transformation / degradation activities within habitat types that are occupied by flora species of conservation importance will ultimately result in significant impacts on these species and their population dynamics. Effects of this impact are usually permanent and recovery or mitigation is generally not perceived as possible.

One of the greatest drawbacks in terms of limiting this particular impact is that extremely little information is available in terms of the presence, distribution patterns, population dynamics and habitat requirements of Red Data flora species in the study area. In order to assess this impact an approach it is therefore necessary to assess the presence/ distribution of habitats frequently associated with these species. Furthermore, by applying ecosystem conservation principles to this impact assessment and subsequent planning and development phases, resultant impacts will be limited to a large extent.

The presence of Red Data flora species within the study area was confirmed during the site investigations. Furthermore, the likelihood of other Red Data flora species occurring within the parts of the study area is likely as these areas were found to be highly suitable for these species.

6.7.4.2 Direct Impacts on Threatened Fauna Species

Direct threats to threatened fauna species is regarded low in probability, mainly as a result of the ability of fauna species to migrate away from areas where impacts occur, also considering the type of development and activities. Probably the only exception to this statement will be in the event where extremely localised habitat that are occupied by threatened fauna species are impacted by construction and operational activities to the extent that the habitat no longer satisfy the habitat requirements of the particular species, or where an increase in the isolation and fragmentation factors renders the remaining habitat inadequate. Specific reference is made of riparian and moist grassland habitat types that occur in the study area as well as certain grassland areas where the Sungazer lizard occurs.

Most of the threatened fauna species potentially occurring in the study area have relatively wide habitat preferences and ample suitable habitat is presently available throughout the study area. To place this aspect into context, it is estimated that habitat loss and transformation resulting from often overlooked impacts, such as overgrazing, infestation by invasive shrubs and agriculture probably contribute more to impacts on most threatened fauna species than this development. However, some Red Data fauna species occur that have specific habitat requirements.

The presence of Red Data fauna species was confirmed during the site investigations. Furthermore, the likelihood of other Red Data fauna species occurring within the parts of the study area is likely as these areas were found to be highly suitable for these species.

6.7.4.3 Destruction of Sensitive / Pristine Habitat Types

The loss of pristine habitat types or habitat that are regarded highly sensitive due to limited presence in the larger region (atypical habitat) represents a potential loss of habitat and biodiversity on a regional scale. Sensitive habitat types include mountains, ridges, koppies, wetlands, rivers, streams and localised habitat types of significant physiognomic variation and unique species composition. These areas represent centres of atypical habitat and contain biological attributes that are not frequently encountered in the greater surrounds. A high conservation value is generally ascribed to floristic communities and faunal assemblages that occupy these areas as they contribute significantly to the biodiversity of a region.

Furthermore, these habitat types are generally isolated and are frequently linear in nature, such as rivers and ridges. Any impact that disrupts this continuous linear nature will risk fragmentation and isolation of existing ecological units, affecting the migration potential of some fauna species adversely, pollinator species in particular.

Micro-habitat conditions are changed as a result of the removal of the vegetation layer, affecting shade conditions, habitat competition, germination success of the herbaceous layer, etc. and is likely to result in the establishment of a species composition that is entirely different than original conditions and the immediate surrounds, in many cases also comprising species of an invasive nature, particularly shrubs.

Extensive parts of the study area are regarded highly sensitive and are highly likely to be occupied by a diverse species composition as well as flora and fauna species of conservation importance.

6.7.4.4 Direct Impacts on Common Fauna Species

The likelihood of this impact occurring is relatively low as a result of the ability of animal species to migrate away from direct impacts. The tolerance levels of common animal species occurring in the study area is of such a nature that surrounding areas will suffice in habitat requirements of species forced to move from areas of impact. It is also unlikely that the conservation status of common animal species will be affected as a result of direct and indirect impacts of power lines on these species and their habitat.

The extensive nature of the existing development has resulted in direct impacts on fauna species, in spite of the ability to avoid direct contact. It is however noted that the impact will be limited to small areas within the existing site area during construction-like activities.

6.7.4.5 Floristic Species Changes Subsequent to Development

This impact is regarded an indirect impact. The transformation of grassland habitat during the construction process will inevitably result in the establishment of habitat types that are not considered representative of the region. While the impacts are generally regarded to be of low severity, impacted areas are frequently invaded by species not normally associated with the region (exotic and invasive species). In addition, many species that are not necessarily abundant in the region will increase in abundance as a result of more favourable habitat conditions being created as a result of habitat manipulation activities (encroacher species). This effect is more pronounced in the floristic component, but changed habitat conditions in the habitat will inevitably imply changes in the faunal component that occupies the habitat.

If left unmitigated, this risk will result in decreased habitat, increased competition and lower numbers of endemic biota, the genetic pool of species might eventually be influenced by the introduction of non-endemic species.

Different faunal assemblages and plant communities have developed separate gene structures as a result of habitat selection and geographical separation and the introduction of individuals of the same species that might be genetically dissimilar to the endemic species might lead to different genetic selection structures, eventually affecting the genetic structure of current populations and assemblages.

Construction will result in alteration of the vegetation in parts of the study area and it is likely that the current vegetation will become infested with weeds and invasive species.

6.7.4.6 Faunal Interactions with Structures, Servitudes and Personnel

It should be noted that animals generally avoid contact with human built structures, but do grow accustomed to structures after a period. While the structures are usually visible as a result of clearance around footprints areas, injuries and death of animals do occur sporadically as a result of accidental contact. An aspect that is of concern is the presence of vehicles on access roads and infrastructure servitudes, leading to road kills, particularly amongst nocturnal animals that are abundant in the study area. This impact was frequently observed in the study area during the site investigation period.

Alteration of habitat conditions within the development areas does not necessarily imply a decrease in faunal habitation. These areas are frequently preferred by certain fauna species. The establishment of a dominant grass layer generally results in increased presence of grazer species, which might lead to an unlikely, but similar increase in predation within these areas.

The presence of personnel within the development area during construction and maintenance periods will inevitably result in some, but normally limited, contact with animals. While most of the larger animal species are likely to move away from human contact, dangerous encounters with snakes, scorpions and possibly larger predators always remain likely. Similarly, the presence of humans within areas of natural habitat could potentially result in killing of animals by means of snaring, poaching, poisoning, trapping, etc.

The nature of the development has at most resulted in indirect impacts on the movement patterns of fauna species in some parts.

6.7.4.7 Impacts on Surrounding Habitat / Species

Surrounding areas and species present in the direct vicinity of the study area could be affected by indirect impacts resulting from construction and operation activities. This indirect impact could potentially include all of the above impacts, depending on the sensitivity and status of surrounding habitat and species as well as the extent of impact activities. Considering the type of development, the extent of this impact is expected to be relatively small.

The indirect nature of this impact dictates that potential impacts spreading from the construction-like activities into bordering areas is likely to affect natural habitat adversely.

6.7.4.8 Cumulative Impact on SA's Conservation Obligations and Targets

This impact is regarded a cumulative impact since it affects the status of conservation strategies and targets on a local as well as national level and is viewed in conjunction with other types of local and regional impacts that affects conservation areas. The importance of regional habitat types is based on the conservation status ascribed to vegetation types, which include an Endangered (Soweto Highveld Grassland) and Vulnerable (Amersfoort Clay Highveld Grassland) vegetation types. In spite of limited transformation indicated by the development process, a loss of pristine parts of these vegetation types is nonetheless expected.

Loss of parts of the Endangered and Vulnerable grassland vegetation types is a limited, but nonetheless important, indirect impact on the conservation status of the regional vegetation types.

6.7.4.9 Cumulative Increase in Local and Regional Fragmentation / Isolation of Habitat

Uninterrupted habitat is a precious commodity for biological attributes in modern times, particularly in areas that are characterised by moderate and high levels of transformation. The loss of natural habitat, even small areas, implies that biological attributes have permanently lost that ability of occupying that space, effectively meaning that a higher premium is placed on available food, water and habitat resources in the immediate surrounds. This, in some instances might mean that the viable population of plants or animals in a region will decrease proportionally with the loss of habitat, eventually decreasing beyond a viable population size.

The danger in this type of cumulative impact is that effects are not known, or is not visible; with immediate effect and normally when these effects become visible they are beyond repair. Linear developments affect the migratory success of animals in particular.

An important mitigation measure in this regard is to utilise existing causal factors of habitat fragmentation. One factor that will be taken into consideration is the presence of existing power lines in the study area. Habitat fragmentation will not be increased significantly when new power lines are placed adjacent to existing lines or other types of linear structures, such as roads. In contrast, constructing new power lines through areas of unfragmented habitat, the adverse effects of habitat fragmentation and isolation will be maximised. Therefore, where potential servitudes are presented with similar sensitivities, a potential corridor with an existing servitude might result in one being more suitable for the proposed development than an option affecting an area of largely untransformed habitat. Unfortunately this is not always a clear-cut case as it is heavily dependent on the local and regional sensitivity of the existing line, which might be located in areas of high sensitivity, while a line going through untransformed habitat might represent impacts of lower significance in terms of other types of impacts.

Although the general region is characterised by moderate levels of transformation, this ongoing operation / maintenance forms part of a series of impacts on remaining natural habitat in the region.

6.7.4.10 Cumulative Increase in Environmental Degradation

Cumulative impacts associated with this type of development will lead to initial, incremental or augmentation of existing types of environmental degradation, including impacts on the air, soil and water present within available habitat. Pollution of these elements might not always be immediately visible or readily quantifiable, but incremental or fractional increases might rise to levels where biological attributes could be affected adversely on a local or regional scale. In most cases are these effects are not bound and is dispersed, or diluted over an area that is much larger than the actual footprint of the causal factor.

Similarly, developments in untransformed and pristine areas are usually not characterised by visibly significant environmental degradation and these impacts are usually most prevalent in areas where continuous and long-term-impacts have been experienced. Particular reference is made to the use of treated process water for irrigation.

6.7.4.11 Impacts associated with the New Service Road

The extent and significance of the proposed new service road is expected to be significant and severe, as it will result in the construction of an entirely new road. In particular, sensitive habitat, such as wetlands and natural grassland (Amersfoort variation, Vulnerable) will be affected adversely by the construction / maintenance and operational activities. The natural grassland component, which was ascribed a medium-high ecological

sensitivity, will comprise approximately 64% of the proposed route. Alternatives to limit the construction / maintenance of additional watercourse crossings should be investigated.

The increase in habitat fragmentation and isolation are particularly important aspects that need to be minimised.

6.7.4.12 Wetland Undermining

Effects of surface dewatering remain one of the most significant impacts that could potentially destroy wetlands within the affected areas. The assessment of potential and likely impacts indicates a significant impact on the status and functionality of affected wetlands. A precautionary approach is therefore strongly recommended in this instance. Furthermore, surface impacts resulting from activities near, or within, the wetland areas (including channelled valley bottoms and hillslope seepages), are likely to result in significant adverse impacts on the status and functionality of the wetlands. Refer to further impacts to wetland ecology in **Section 6.5** (Wetlands).

6.7.5 Recommendations

Considering the types of activities that will take place during the construction and decommissioning phases, impacts on sensitive biodiversity attributes are nonetheless expected to occur, notwithstanding the implementation of mitigation measures, hence the relative high level of impact significance rating after the implementation of mitigation measures. Direct impacts on Red Data flora and fauna species as well as potential destruction of natural habitat are regarded unavoidable and it is strongly recommended that sensitive habitat types be excluded from the proposed development. One of the potential problems that will be encountered is the presence of Red Data fauna species within natural grassland habitat. An existing programme is in place where Sungazer lizards are located and removed to a suitable locality prior to the commencement of construction activities. This programme should be expanded to include other Red Data fauna and flora species and relevant identification and location programmes should be launched in the summer period when these species are most prevalent.

Furthermore, construction and operational activities should be timed to coincide with the most likely absence of migratory species, i.e. the winter period. Areas that should be entirely excluded from the proposed development include outcrops and ridges as well as the wetland/ riparian habitat types. In addition, a suitable buffer zone around these areas should also be included as part of a ~~"n~~o-go" zone. It was furthermore indicated that limited areas of moist grassland habitat will be affected by the proposed activity, but construction will be planned in such a manner that minimal infrastructure is placed within these areas. While any impact within this highly sensitive habitat is regarded severe, significant and undesirable, it was indicated that the exclusion of these areas will result in severe effects on the livelihood of the project. It is therefore strongly recommended that should this activity be allowed within this sensitive habitat type, site specific mitigation measures be put into place in order to prevent, monitor and control activities within these areas.

Areas of lower ecological sensitivities are not expected to be affected significantly by the proposed development and the implementation of generic mitigation measures are expected to prevent significant impacts. These areas should ideally be utilised for the placement of any new footprints for infrastructure and other activities that could potentially affect more sensitive areas. In addition to the proposed extraction of gas from the area, it was also indicated that excess water utilised during the process will be stored in the process water dam and utilised for irrigation of agricultural areas since it is rich in nutrients commonly used for soil enrichment. Extreme caution needs to be taken during the process so that this water does not affect nearby riparian and wetland environments, particularly in view of the proximity of some agricultural areas to riparian environments.

6.8 Waste

The UCG process has some inherent process benefits that are commensurate with the National Integrated Waste Management Strategy in terms of waste minimisation.

The waste impact associated with traditional mining operations in terms of waste ore and ash is not existent due to the in-situ and underground coal gasification process. The extraction of gas and its conversion to energy has followed a process of least waste production.

The waste stream of concern is related to the high total dissolved solids condensate stream. This stream also has concentration of hydrocarbon-based toxics that can pose a risk to the environment. This stream has been addressed in terms of the advanced wastewater treatment plant which results in a final treated effluent stream with low levels of TDS and toxic hydrocarbons such as poly-aromatic hydrocarbons (PAH) and phenols. The treatment is via an efficient route of activated carbon adsorption. The brine-rich residual waste stream has been to date disposed of to a designated landfill site. However, Eskom will also consider other options such as recovery and re-use option for the brine stream going forward in the parallel EIA process and forwards in the ongoing research process.

6.8.1 Potential Impacts

Table 41: Potential impacts

Phase	Potential Impacts
Construction	• Contamination of surface during drilling with machine oils • Contamination of site with general and hazardous waste during construction
Operations	• Leakage of combustion condensate onto land along pipeline route • Untreated water discharge into environment • UCG condensate treatment and proposed irrigation • Leakage of hydrocarbons in the gas treatment plant • Improper disposal of admin-based waste water, brine, solid sludge and particulates and spent activated carbon
Decommissioning	• Similar to construction phase impacts in terms of general and hazardous waste generation and disposal • Ingress of upper groundwater into combustion void with consequent build-up of contaminants of concern (oils, salts and metals)

6.8.2 Recommendations

It is recommended that the monitoring, analysis and reporting for the various process and effluent streams continue so that there is an adequate databank of objective information to fully comprehend the impact of the proposed development.

The Integrated Water and Waste Management Plan (IWWMP) for the ongoing Eskom UCG Project as it unrolls has been undertaken within the context of latest environmental legislation in South Africa. The legislative underpinnings and key management strategies relate to pollution prevention, waste minimisation, adoption of the precautionary principle, integrated water and water management, cradle to grave analysis and management and all measures that are protective of water resources.

The IWWMP has been backed up by Environmental Scoping Studies in the parallel EIA process, various specialist studies that have a bearing on IWWMP, and the compendium of hydrogeological studies, modelling

and ground and surface water monitoring spanning several years. The proposed development has adopted a precautionary approach of ensuring opportunity for collection of baseline ~~-no~~ development" scenario and the gradual stepping up of UCG syngas production.

Undoubtedly the overall system of the three (3) aquifers and its interaction with surface ecology and water systems needs to be well understood and scientifically management with the requisite regulatory measures in place. Ultimately the development after due consideration needs to proceed with clear licences and permits for water usage, generation, treatment and disposal and for waste generation, treatment, containment and safe disposal.

Finally the emerging Environmental Programme (EMPr) emanating from the requirements of the IWWMP and the general environmental impact assessment process will enable the development to occur within a framework that is highly regulated and supported by a dynamic EMPr preventative strategy.

6.9 Socio-Economic

From a social perspective, the respective change processes and the potential impacts that could be experienced by the receiving environment because of the construction and operation of the proposed project and its associated infrastructure are as follows:

- Geographical processes refer to the processes that affect the land uses of the local area.
- Demographical processes refer to the movement and structure of the local community.
- Institution and Legal processes refer to the processes that affect service delivery to the local area.
- Socio-cultural processes refer to the processes that affect the local culture of an affected area, i.e. the way in which the local community live (however, sometimes different cultural groups occupy the same geographical area and these groups are seldom homogenous).

6.9.1 Expectant Change and Resultant Impacts – Social

A summary of the expected impacts are as per the table below.

Table 42: Expected change and resultant impacts

Change Processes	Expected Change and Resultant Impacts	Project Phase(s)
Geographical	**Change in access to resources that sustain livelihoods:** It is not foreseen that the proposed UCG plant will lead to a change in access to resources that sustain livelihoods, as the plant and the bulk of the associated infrastructure will be located on Eskom property.	Construction, extending into Operation
	Land acquisition and disposal, including availability of land: No impact foreseen in this regard, as the project is located on Eskom property.	Construction, extending into Operation
Demographical	**Arrival of Construction workers:** At the time of the study, the estimated size of the construction team was not known. It was therefore difficult to determine the social impact as a result of an influx of construction workers, as the extent and significance of the impact is largely dependent on the number of people.	Construction
	Influx of unemployed work seekers: Given the skills required for the respective construction processes, it is highly unlikely that a job seeker will find formal employment by loitering at the construction camp or site, which would be a natural deterrent to a further influx of job seekers.	Construction, extending into Operation

Change Processes	Expected Change and Resultant Impacts	Project Phase(s)
	Relocation of Households: The relocation process was completed in 2011 and no further relocation will be required.	Pre-construction
Institutional and Legal	**Change in community infrastructure (additional demand on services):** The additional demand on municipal services is a point of concern, as it would appear that most of the surrounding areas (most notably Vlakplaats and Daggakraal) are poorly developed and characterised by poverty.	Construction, extending into Operation
	Change in housing needs/demands: It seems likely that the construction team will be housed in the existing single quarters at the mining offices. The impact is therefore regarded as negligible and has not been assessed in any further detail.	Construction, extending into Operation
	Corporate Social Investment: The Eskom Development Foundation (EDF) delivers on Eskom's CSI objectives by supporting economic and social projects initiated by registered Small, Medium and Micro Enterprises (SMMEs), with a special focus on communities within which Eskom operates its capital expansion projects.	Construction, extending into Operation
Socio-Cultural	**Dissimilarity in social practices:** As it is Eskom's intention to house construction workers on-site in the existing single quarters, it is not expected that dissimilarity in social practices would be evident to the degree that it would affect a large segment of the population.	Construction
	Conflict: At the time of the study, there was no apparent conflict within the local community or between the local community and the project proponent (Eskom) over the proposed UCG plant. The situation is unlikely to change if the project processes proceed in an open and transparent manner.	Not applicable
	Change in sense of place: It is unlikely that the UCG plant itself will change local residents' sense of place, as the plant will be located in the vicinity of the existing Majuba Power Station. Compared to the existing power station, the plant will be significantly smaller and as it will be placed in an area that is already regarded as 'spoilt', it is not foreseen that it will have a primary impact on sense of place.	Construction, extending into Operation

6.9.2 Expectant Change and Resultant Impacts – Economic

- Industrial developments often contribute indirectly to the regional and national economy by improving infrastructure, adding to the country's productive capacity, contributing to the country's capital goods and enabling economic growth. In the case of this project however, the long-term viability of the project still has to be proven and the project will not produce a saleable commodity. As such this impact cannot be defined accurately enough to be rated.
- Use of the farm for agriculture after mining has ceased and the land has been rehabilitated may be possible if the productive capacity of the land is intact as planned and Eskom rents the land to farmers. However, the practicality of this cannot be assessed as no precedence exists for this situation.
- Furthermore, due to the fact that UCG technology is still under research (and considering that the main development would only be localized to one farm with an existing workforce), no to very little money will be spent as part of the social and labour plan. Employment will be evaluated and as far as possible local members of the community will be considered for employment.

6.9.3 Recommendations

- Ensure that social issues identified during the EIA phase are addressed during construction. This could be done by engaging social specialists where necessary or by ensuring that ECOs used during construction

have the necessary knowledge and skills to identify social problems and address these when necessary. Guidelines on managing possible social changes and impacts could be developed for this purpose.

- Always inform neighbouring landowners beforehand of any construction activity that is going to take place in close proximity to their property. Prepare them on the number of people that will be on site and on the activities they will engage in.
- Ensure that Eskom employees are aware of their responsibility in terms of Eskom's relationship with landowners and communities surrounding linear infrastructure. Implement an awareness drive to relevant sections to focus on respect, adequate communication and the 'good neighbour principle'.
- Incorporate all mitigation measures in the Social Impact Assessment (SIA) that are relevant to the construction phase in the EMP to ensure these are adhered to by Eskom and the contractor.

6.10 Air Quality

6.10.1 Emissions Inventory

The emissions inventory has been developed in conjunction with the staff from Eskom, who provided mass balance calculations, input parameters and monitored data from various sources. Point sources are identified as non-mobile stacks or sources associated mainly with industrial or commercial operations. In the case of the UCG plant, this is only one point source, the flaring stack. This stack is used to direct flue gas from the UCG pipeline under emergency conditions, the only scenario investigated was the worst-case emergency flaring of flue gas. The emissions inventory and model input are presented in **Table 43** and **Table 44**.

Table 43: Model input parameters

Parameters	Flare
Height (m)	59.4
Diameter (mm)	850
Volumetric Flow (Nm^3/hr)	70,000
Exit Temperature (°C)	1200

Table 44: Exhaust emissions during flaring

Component	Quantity	Units	Emission Rate (g/s)
Particulate Matter (PM)	< 50	mg/Nm^3	7.80
Sulphur Dioxide (SO_2)	1,596	mg/Nm^3	102.74
Nitrogen Dioxide (NO_2)	942	mg/Nm^3	57.65
Carbon Monoxide (CO)	1,024	mg/Nm^3	49.85
Volatile Organic Compounds (1)	226	mg/Nm^3	14.52
Hydrogen Sulphide (H_2S)	17	mg/Nm^3	1.14
Ammonia (NH_3)	10	mg/Nm^3	0.67

(1) Reported as benzene

6.10.1.1 Potential Impacts

- **Construction activities**

During the construction-like activities (i.e. maintenance, repairs, and rehabilitation activities) it is expected that, the main sources of impact will result due to vehicle movement within the plant area. These predicted impacts cannot be quantified, primarily due to the lack of detailed information related to scheduling and positioning of

construction related activities. Instead a qualitative description of the impacts will be provided. This will involve the identification of possible sources of emissions and the provision of details related to their impacts.

Construction is of a temporary nature with a definite beginning and end. Construction usually consists of a series of different operations, each with its own duration and potential for dust generation. Dust emission will vary from day to day depending on the phase of construction, the level of activity, and the prevailing meteorological conditions[31].

The following possible sources of fugitive dust and particulate emissions were identified as activities which could potentially generate air pollution during construction-like / maintenance / rehabilitation operations:

a) Demolition and debris removal:

- Demolition of obstacles such as boulders, trees, etc.;
- Loading of debris into trucks;
- Truck transport of debris; and
- Truck unloading of debris.

b) Site preparation (earthworks):

- Bulldozing;
- Scrapers unloading topsoil;
- Scrapers in travel;
- Scrapers removing topsoil;
- Loading of excavated material into trucks;
- Truck dumping of fill material, road base, or other materials;
- Compacting;
- Motor grading; and
- Excavating.

c) General Construction:

- Vehicular traffic;
- Portable plants – aggregate processing; and
- Concrete Mixing.

- ***Normal Operations***

During the normal operational phase there is estimated to be no emissions emitted from the project, as all the syngas will be piped to Majuba Power Station. It should also be noted that during this phase the amount of gas generated has been limited with only a few tests run with minimal co-firing events required.

[31] *Ibid.* Footnote 12.

- ***Upset Conditions – Flaring***

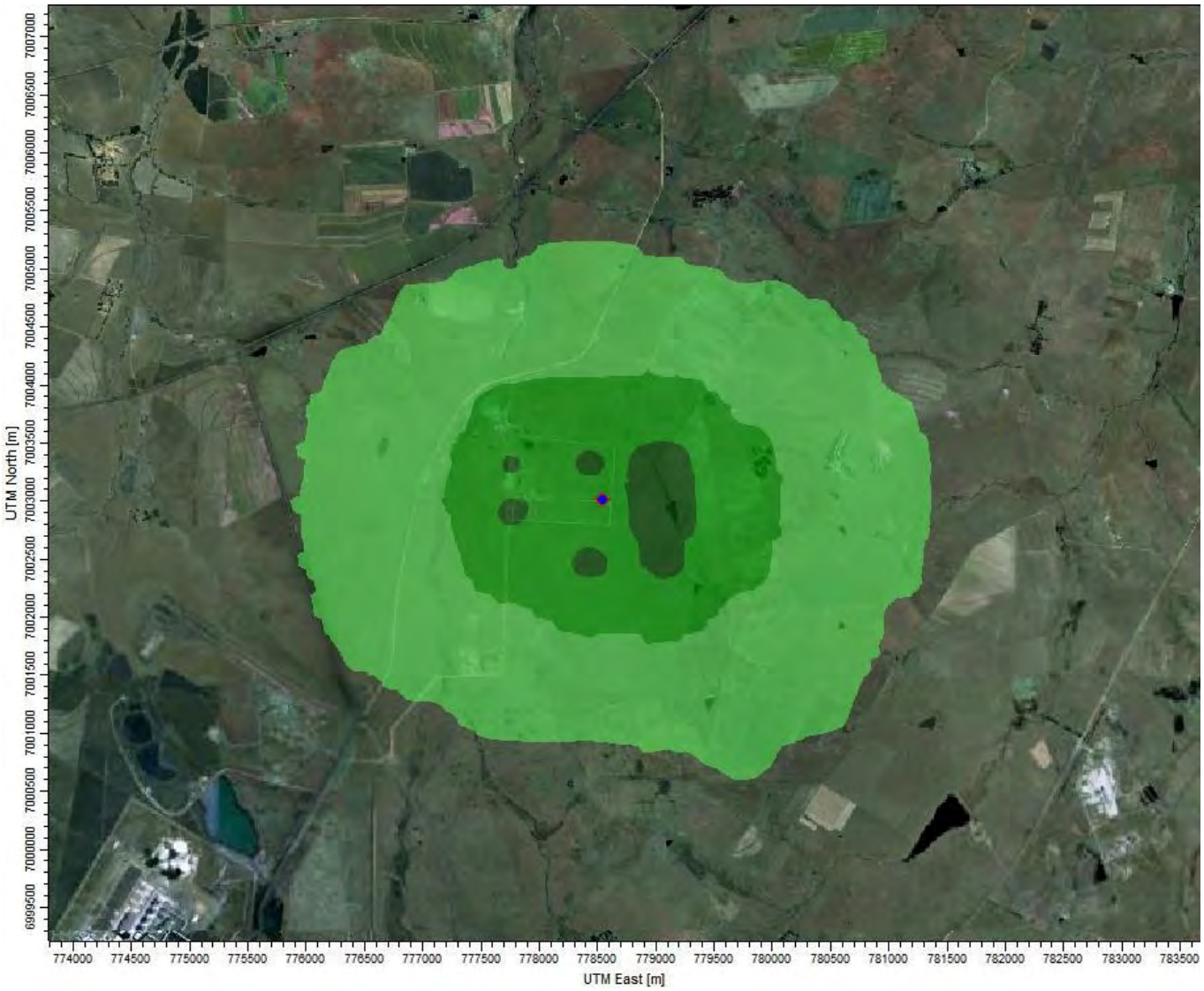
The dispersion modelling results from this worst-case emergency scenario is detailed below. It should be noted that this scenario will not happen every day of the year but only when there is an emergency. The results below present the absolute highest values that were experienced at a receptor for the average period being presented. Both daily and annual average predicted ground level concentrations are thus an over prediction of impacts as these results assume that flaring occurred 24 hours a day 365 days in a year.

Table 45: Maximum ambient ground level concentrations from the UCG project under flaring conditions

Concentration (µg/m³)	Maximum Hourly Average (µg/m³)	Maximum Daily Average (µg/m³)	Maximum Annual Average (µg/m³)
Particulate Matter (PM)	2.86E+00	7.63E-01	1.14E-01
Sulphur Dioxide (SO_2)	3.77E+01	1.00E+01	1.50E+00
Nitrous dioxide (NO_2)	2.12E+01	5.64E+00	8.43E-01
Carbon Monoxide (CO)	1.83E+01	4.87E+00	7.29E-01
Volatile Organic Compounds (1)	5.33E+00	1.42E+00	2.12E-01
Hydrogen Sulphide (H_2S)	4.19E-01	1.12E-01	1.67E-02
Ammonia (NH_3)	2.44E-01	6.51E-02	9.74E-03

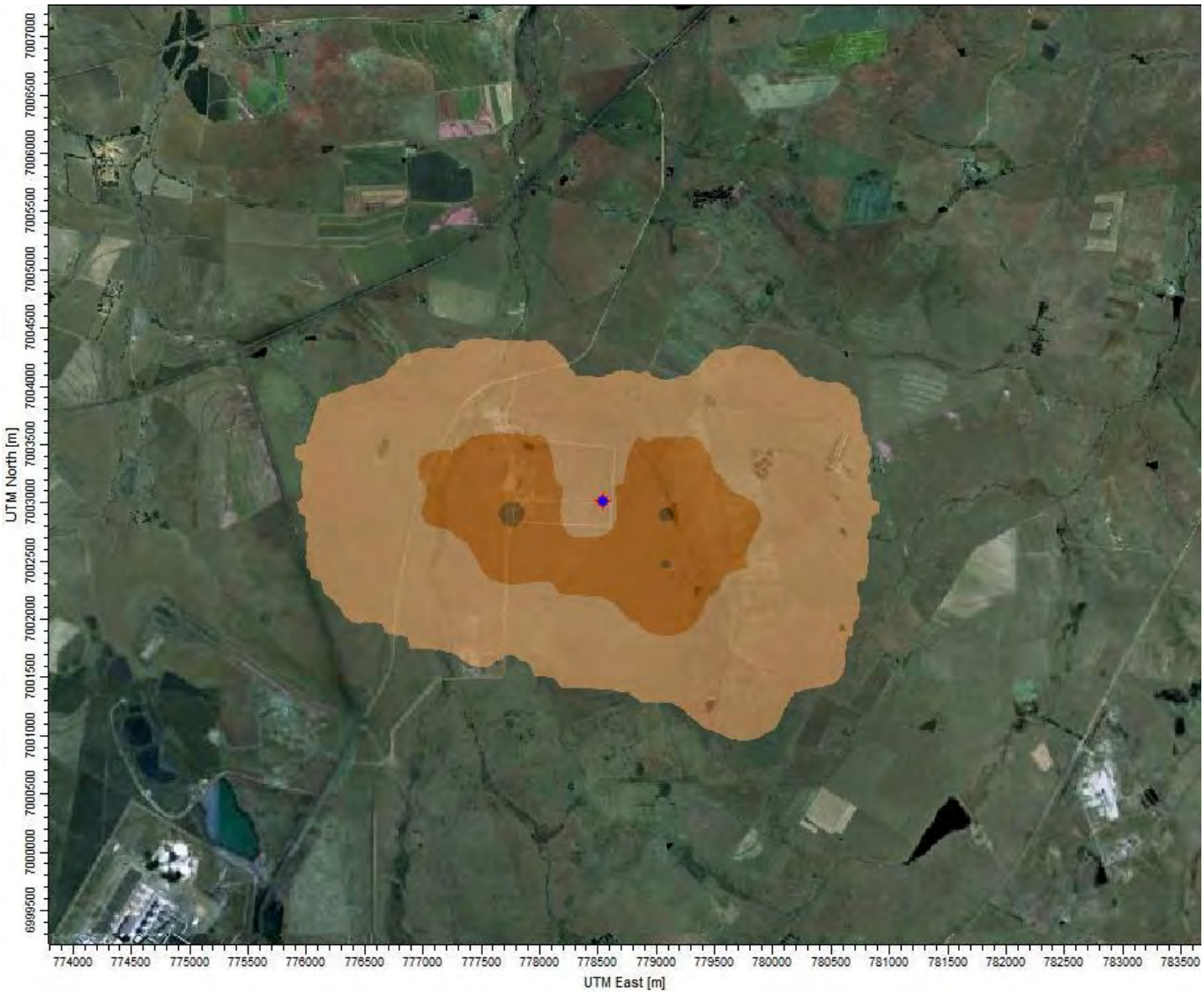
(1) Reported as benzene

Based on the maximum predicted ground level concentrations presented in **Table 45**, as well as the isopleths outlining the spatial distribution of potential impacts presented in **Figure 48** to **Figure 50** all predicted ground level concentrations over an hourly, daily and annual averaging period are noted to fall well below the respective health risk standards, guideline and thresholds for these pollutants.



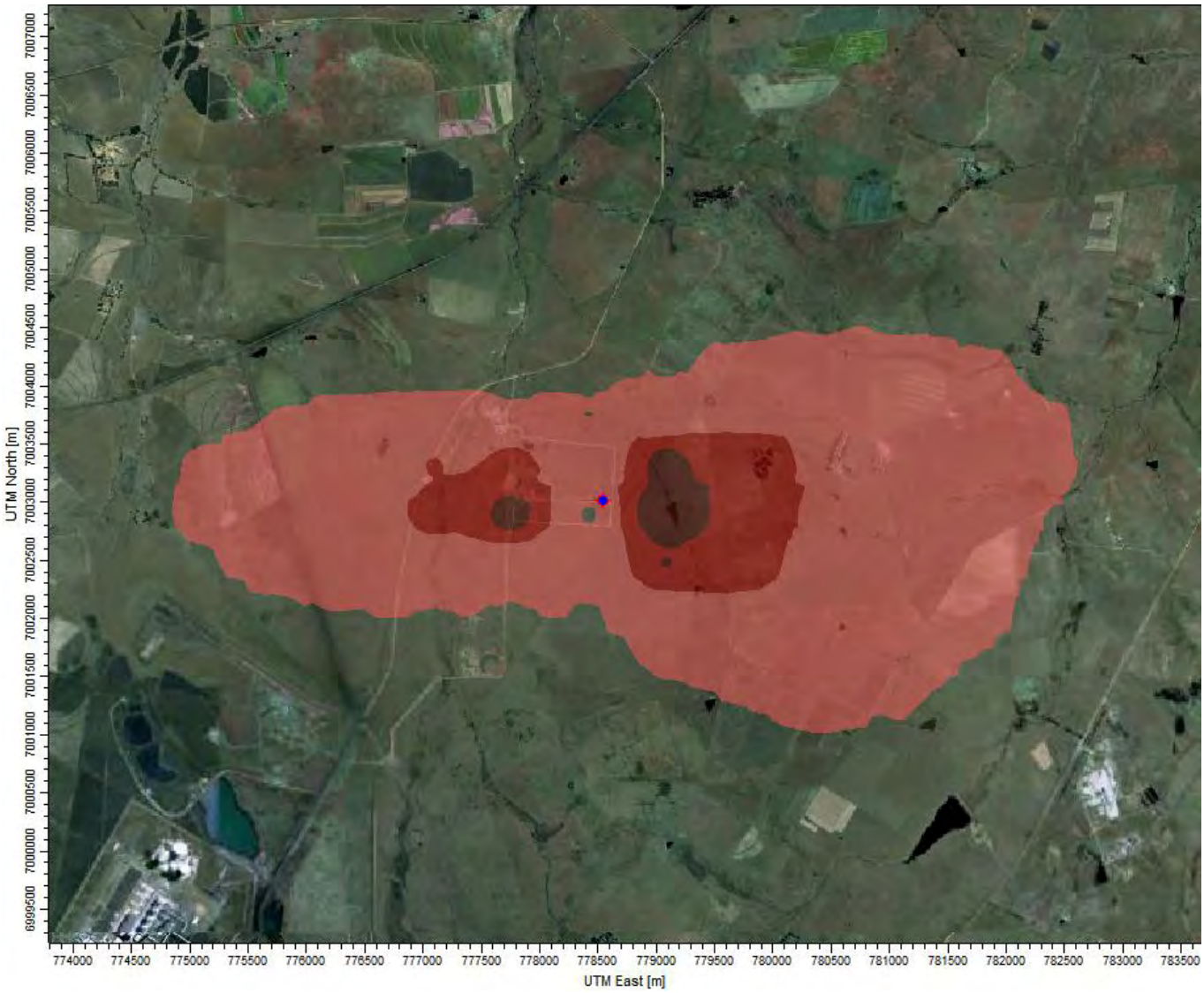
Pollutant key			
Particulate Matter (PM)	2.34E+00	1.56E+00	7.80E-01
Sulphur Dioxide (SO_2)	3.08E+01	2.05E+01	1.03E+01
Nitrous dioxide (NO_2)	1.73E+01	1.15E+01	5.76E+00
Carbon Monoxide (CO)	1.50E+01	9.97E+00	4.98E+00
Volatile Organic Compounds (Benzene)	4.36E+00	2.90E+00	1.45E+00
Hydrogen Sulphide (H_2S)	3.42E-01	2.28E-01	1.14E-01
Ammonia (NH_3)	2.00E-01	1.33E-01	6.66E-02

Figure 48: Hourly average predicted ground level concentrations for various pollutants (µg/m³)



Pollutant key			
Particulate Matter (PM)	7.02E-01	4.68E-01	2.34E-01
Sulphur Dioxide (SO_2)	9.25E+00	6.16E+00	3.08E+00
Nitrous dioxide (NO_2)	5.19E+00	3.46E+00	1.73E+00
Carbon Monoxide (CO)	4.49E+00	2.99E+00	1.50E+00
Volatile Organic Compounds (Benzene)	1.31E+00	8.71E-01	4.36E-01
Hydrogen Sulphide (H_2S)	1.03E-01	6.85E-02	3.42E-02
Ammonia (NH_3)	5.99E-02	4.00E-02	2.00E-02

Figure 49: Daily average predicted ground level concentrations for various pollutants assessed (µg/m³)



Pollutant key			
Particulate Matter (PM)	7.80E-02	5.46E-02	2.34E-02
Sulphur Dioxide (SO_2)	1.03E+00	7.19E-01	3.08E-01
Nitrous dioxide (NO_2)	5.76E-01	4.04E-01	1.73E-01
Carbon Monoxide (CO)	4.98E-01	3.49E-01	1.50E-01
Volatile Organic Compounds (Benzene)	1.45E-01	1.02E-01	4.36E-02
Hydrogen Sulphide (H_2S)	1.14E-02	7.99E-03	3.42E-03
Ammonia (NH_3)	6.66E-03	4.66E-03	2.00E-03

Figure 50: Annual average predicted ground level concentrations for various pollutants assessed (µg/m³)

Due to flaring as indicated in **Table 45**, hydrogen sulphide and ammonia is predicted to be released, these have the potential to result in noticeable odours. Odour thresholds are defined in several ways including absolute perception thresholds, recognition thresholds and objectionability thresholds. At the perception threshold one is barely certain that an odour is detected but it is too faint to identify further. Recognition thresholds are normally given for 50% and 100% recognition by an odour panel. Odour thresholds published in the literature for hydrogen sulphide and ammonia is given together with the WHO guidelines.

Table 46: Odour threshold values for hydrogen sulphide

Pollutant	Detection Threshold		Odour Recognition Threshold		Other Odour Thresholds	WHO GV (30min) [32]
	AIHA[33]	Devos[34]	100% Recognition	50% Recognition		
	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Hydrogen Sulphide	---	---	1430	11.2	4.29[35]	7
Ammonia					340	

The hourly average hydrogen sulphide and ammonia ground level concentration converted to an equivalent 10 minute average using Beychok[36] are 5.10E-01 µg/m³ and 3.0E-01 µg/m³ respectively, which are well below the WHO guideline values cited for these pollutants. No detectable or perceptible odour should thus be noted from these flaring operations on site.

6.10.2 Recommendations

6.10.2.1 Construction Phase

During the construction phase the pollutants likely to be emitted are Particulate Matter (PM). The emissions are likely to be generated by the vehicle movement on site and exposed soil to wind erosion. The dust fallout generated by this phase will be more of a nuisance and will not cause a health effect, due to the specified nature of the activity. The dust would likely be confined to fall out within 2 km of the site. If the mitigation measures mentioned in the EMPr are followed, the impact from the construction phase can be reduced thus resulting in a low impact rating.

6.10.2.2 Normal Operational Phase

During normal operations at the site all emissions will be contained within piping and in the processes. Normal operations will commence after the construction phase. It is envisaged that there will be no emissions from this phase of the project.

6.10.2.3 Emergency Incident

During the normal operations, there is a likelihood that some occurrence could result in the syngas being flared. The occurrence could be on site during the production and cleaning of the gas or at the end of the piping line,

[32] ***World Health Organisation, 2000.*** *WHO Guideline Value.*
[33] ***AIHA, 1989.*** *Odour Thresholds for Chemicals with Established Occupational Health Standards, Akron, Ohio, American Industrial Hygiene Association.*
[34] ***Devos M, Patte F, Rouault J, Laffort P and van Gemert LJ (Eds), 1990****. Standardized Human Olfactory Thresholds, New York, Oxford University Press.*
[35] *South African guideline (personnel communication, M Lloyd, 8/10/98).*
[36] ***Beychok; M.R, 2005.*** *Fundamentals of Stack Gas Dispersion.*

namely at the Majuba Power Station. The emissions associated with the flaring are predominantly Hydrogen sulphide and other elements that are found in the syngas.

The worst-case scenario of the flare being active for an hour under the worst meteorological conditions, the maximum concentration is well below the international standards and also below the odour thresholds. The dispersion plume does not extend far beyond the project boundary and can be reduced over a short time period.

The impact from flaring is rated at medium due to the fact that the plume has the potential to spread over a distance. It should be noted that the sensitive receptors in the region is located more than 4 km from the facility.

6.11 Heritage

No sites, features or objects dating to the Stone Age and Iron Age were identified in the specific study area. The following sites, features or objects of cultural significance were however identified in the greater study area and are mentioned for completeness:

6.11.1 Farmsteads

A number of old farmsteads and associated outbuildings occur sporadically over the larger area. Central to all is the farmhouse with associated outbuildings and in some cases, associated features such as stock enclosures, sheep dips, etc. located some distance away.

Table 47: Farmsteads found on greater UCG site

Location		
No. 2	S 27.08864	E 29.79753
No. 3	S 27.11389	E 29.80690
No. 6	S 27.10190	E 29.80980
No. 9	S 27.06441	E 29.82947
No. 14	S 27.05712	E 29.84322
No. 15	S 27.05405	E 29.84648
No. 18	S 27.06106	E 29.79941
No. 19 – 21	S 27.08301	E 29.80060

Photograph 16: Farmstead (waypoint #6)

6.11.2 Homesteads

Table 48: Homesteads found on greater UCG site

Description	Location	
No. 10 – Remains of farm labourer homestead, built with locally quarried stone.	S 27.06824	E 29.83339
No. 22 – Remains of possible farm labourer homestead, built with locally quarried stone	S 27.08033	E 29.80186
No. 23 – Remains of possible farm labourer homestead, built with locally quarried stone	S 27.08625	E 29.80386

Photograph 17: Homestead (waypoint #23)

6.11.3 Other Features

Table 49: Other heritage features found on greater UCG site

Description	Location	
No. 4 – Old concrete bridge across an old conveyor route, the latter which was demolished some years ago. The bridge is classified as a rigid frame concrete bridge. At present is serves to give access to a farmstead that is still occupied.	S 27.10438	E 29.80821
No. 17 – A number of small half-moon shaped features on a ridge overlooking a valley. At first it was thought to date to the Anglo-Boer War, where it served as sangars. However, it turned out to be hunting blinds that were used in the recent past.	S 27.05802	E 29.80927

Photograph 18: Old concrete bridge and hunting blinds

6.11.4 Cemeteries and Burial Places

Table 50: Cemeteries and burial places found on greater UCG site

Description	Location	
No. 1 – Single grave of child, now vandalised.	S 27.08807	E 29.79571
No. 5 – Small informal farm labourer cemetery. All graves only marked with stone cairns	S 27.10347	E 29.80232
No. 7 – Small farm labourer cemetery, with at least three burial periods. The remains of an old rondawel shape house is located close by.	S 27.09677	E 29.80940
No. 8 – Large farm labourer cemetery. Few have headstones, making it difficult to determine an exact number.	S 27.09341	E 29.81359
No. 11 – A small informal farm labourer cemetery that can probably be linked to old homestead in record no. 10.	S 27.06903	E 29.83311
No. 12 – Single grave marked with stone cairn. Based on its size, it is probably that of a child.	S 27.06670	E 29.83038
No. 13 – Small farm labourer cemetery with possibly as many as 50 graves.	S 27.06669	E 29.83009
No. 16 – Small farm cemetery of the Swanepoel family, containing at approximately 10 graves. At least four of the people died during 1918.	S 27.05263	E 29.84490
No. 20 – Number of old graves, now vandalised, making it difficult to establish the original number or names of the occupants.	S 27.08567	E 29.80128

Photograph 19: Single grave marker with stone cairn (waypoint #12)

6.11.5 Recommendations

Heritage sites are fixed features in the environment, occurring within specific spatial confines. Any impact upon them is permanent and non-reversible. Those resources that cannot be avoided and that are directly impacted by the proposed development can be excavated / recorded and a management plan can be developed for future action. Those sites that are not impacted on can be written into the management plan, whence they can be avoided or cared for in the future.

Further recommendations include:

- Known sites should be clearly marked in order that they can be avoided during construction activities.
- The contractors and workers should be notified that archaeological sites might be exposed during the construction activities.
- Should any heritage artefacts be exposed during excavation, work on the area where the artefacts were discovered, shall cease immediately and the Environmental Control Officer shall be notified as soon as possible.
- All discoveries shall be reported immediately to a heritage practitioner so that an investigation and evaluation of the finds can be made. Acting upon advice from these specialists, the Environmental Control Officer will advise the necessary actions to be taken.
- Under no circumstances shall any artefacts be removed, destroyed or interfered with by anyone on the site.
- Contractors and workers shall be advised of the penalties associated with the unlawful removal of cultural, historical, archaeological or palaeontological artefacts.

6.12 Visual

The nature of the topography – being gently undulating to flat in parts - has implications for visual intrusion of structures across the area. A structure placed on a higher point in the landscape would typically be visible from a wide area, with a structure placed within a valley bottom being visible from a smaller area. The same principle applies to the viewer‘s position within the landscape setting, with wide-reaching views being visible for a viewer in most locations except for a position within a valley bottom. The nature of the current land cover – mostly open grassland – enhances the visibility of structures, as vegetation does not play an important part in screening objects from view.

Lastly, and very importantly, the omnipresent factor of the Majuba Power Station structure has an important bearing on the visual character and the potential significance of visual intrusion associated with a new development. The power station structure is visible from most parts of the study area and thus a new object in the landscape would be viewed in this context of the view typically being dominated to a large degree by the presence of the power station.

In this context the study area displays a high visual absorption capacity (VAC), with the existing presence of the power station and associated infrastructure in the landscape ~~-o~~ffsetting” the intrusion factor associated with a new development. The converse situation (i.e. the area displaying a low VAC) would be if there was little to no structural components or transformation of the landscape, and in which a new development would thus arguably be highly incongruent in terms of the setting.

Note that the visual considerations were carried out for the potential stack height of 9 m proposed for the Pilot Plant Phase 2. Obviously the stack on the existing infrastructure is significantly lower than that (approximately 2 m in height), it was thus decided to use that information as by default the visual impact would be less and if already deemed not to be an issue, then the existing plant remains a non-issue.

6.12.1 Study area visual character

The above structural components of the landscape influence the visual character of the study area.

The nature of the predominant land-use (livestock farming) and the relatively low level of change to the natural vegetation and landscape that this land-use has resulted in (apart from the introduction of typical rural infrastructure to the landscape such as fencing, feedlots and windmills) entails that the study area displays a largely natural or rural visual character.

A natural / rural character is characterised by a low level of transformation of the natural landscape, with the limited introduction of infrastructure and structural changes to landscape features such as vegetation. However the presence of the Majuba Power Station complex and associated infrastructure has introduced a strong industrial element to the study area. The visual influence of the Majuba Power Station is pervasive over the wider area due to the massive bulk of the power station structure that makes it visible from most parts of the immediate area, even those areas which would normally be shielded from viewing nearby areas due to their landscape position, such as locations within valley bottoms with a limited viewshed. The presence of the power station and other visually prominent infrastructure such as high voltage power lines imbues the study area with a strong industrial visual component.

The study area‘s visual character can thus be described as being rural with a strong industrial component.

6.12.2 Presence of Receptor Locations

Visual impact is related to the presence of human receptors / viewers, thus visual impact is typically experienced from locations inhabited by humans. For the purposes of the study receptor locations have been identified to be locations inhabited by humans, most of which are rural farmsteads as well as worker‘s dwellings. As measurable visual impact is typically limited to 5 km from an object causing the visual impact, receptor locations within a 5 km radius of the study area have been identified.

Within the 5 km radius of the revised development site, 35 (thirty-five) receptor locations have been identified. Most of these are rural farmsteads as well as worker dwellings. The south-western outskirts of the town of Amersfoort is just outside of the 5 km boundary of the study area, and thus the town has been considered as a receptor location where a number of households, especially those on the outskirts of the town would be classified as receptor locations. Taking a risk-averse approach, it has been assumed that all of these receptor locations could be termed potentially sensitive receptors, i.e. receptors that could potentially perceive a visual impact through the introduction of large-scale infrastructure into the setting.

Photograph 20: A receptor location near the Majuba Power Station turnoff from the Perdekop Road

Receptor locations are not only stationary, but can also be roads along which people travel. The main roads in the study area are the N11, running north-south to the east of the study area, the Perdekop Road which runs to the north and west of the study area, and the access road between the N11 and the Majuba Power Station.

A number of smaller district roads bisect the area, including the Bergvliet road running past the old mine, and the Koppieskraal road to the north of the revised study area.

The map overleaf indicates the location of receptor locations within 5 km of the site.

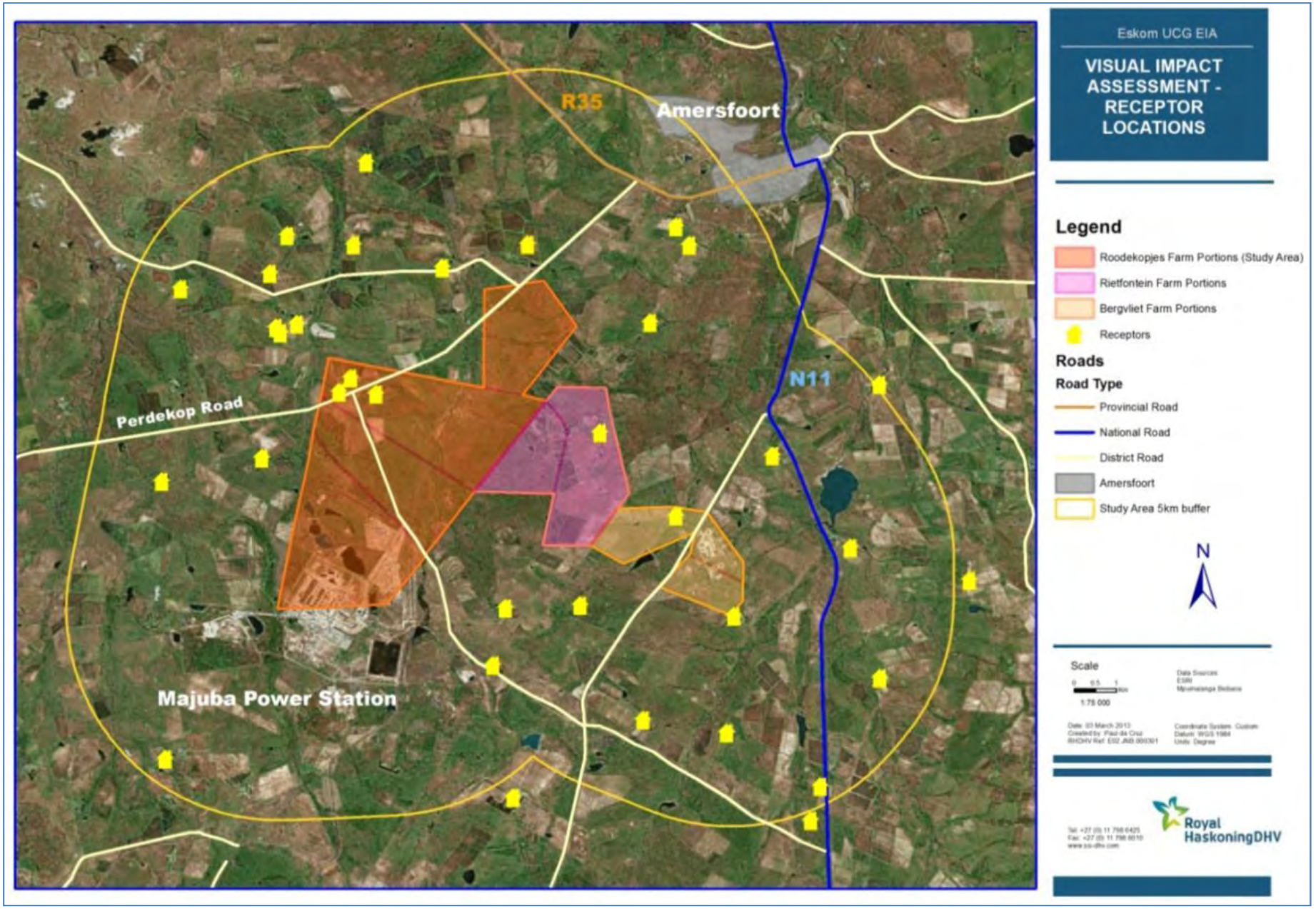


Figure 51: Receptor locations within a 5 km radius of the site

6.12.3 Visual Impact associated with the Gas Treatment Plant

Along with the proposed gasifier units, the GTP is visually the most prominent feature of the existing UCG operations due to the height of some of its components. As described above the GTP has a footprint of is approximately 30 x 60 m and will consist of the following components:

- Heat exchanger – cooling towers;
- Liquid separation vessels;
- Emergency gas flare stack; and
- Auxiliary pumps, motors and other small equipment.

The presence of the stack is important from a visual perspective as the height of the stack makes it visible from around the site. Viewing the stack could be potentially significant due to the presence of a flare (visible flame) if the stack is operational at all times. It should however be noted that the Pilot Plant Phase 1 operation has minimal, episodic flaring operations. The stack and flame can be considered a nuisance factor[37] and importantly would be highly visible at night if operated during that time. This is however noted as being a minimal impact as Gasifier 1 is now effectively is ~~s~~hut down" mode and thus the chance of additional flaring operations is minimal to zero.

Majuba Power Station comprises a number of massive structures and thus dominates the views towards it, especially those views from locations within 1-15 km. For the receptors in the viewshed of the GTP and stack located to the north and north-west, the GTP would be easily overwhelmed by' the view of the power station industrial complex, and is considered to be much less intrusive than if the Majuba Power Station was not there.

A second factor that needs to be considered in terms of the degree of visual intrusiveness of the plant is the relative distance of receptors within the viewshed away from the plant. Beyond a certain distance, even large structures such as multi-storey buildings tend to be much less visible, and are difficult to differentiate from the surrounding landscape. The visibility of an object decreases exponentially with increasing distance away from the object, with maximum impact being exerted on receptors at a distance of 500 m or less. The impact decreases exponentially as one moves away from the source of impact, with the impact at 1,000 m (1 km) being a quarter of the impact at 500 m away (**Figure 52**). At 5,000 m (5 km) away or more, the impact would be negligible.

[37] ***MetroGIS, 2011***. *Visual Impact Assessment for the proposed 40MW Demonstration Plant, Gas Treatment Plant and Gasifier near Amersfoort, Draft Report.*

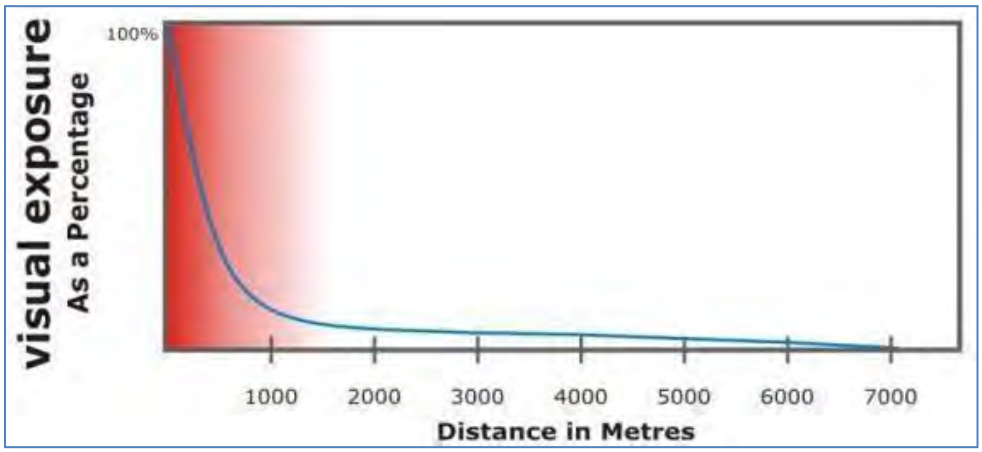


Figure 52: Diagram illustrating diminishing visual exposure over distance

Any receptors within 500 m or less of the GTP would be exposed to the greatest degree of potential visual intrusion. A lesser, but nonetheless potentially high degree of visual intrusion would be associated with receptors located between 500 and 2,000 m of the GTP. It is important to note that no receptor locations fall within these zones of high visual intrusion, partly due to the fact that much of the area of the Roodekopjes property (owned by Eskom) is uninhabited.

The closest receptor locations are over 2.5 km distant. At this distance the visibility and potential visual intrusion factor of the GTP and stack would be greatly reduced. At greater distances beyond 2 km of the plant, the plant and stack would be increasingly difficult to distinguish against the background of the view.

Only four (4) receptor locations that are within the viewshed of the plant are located within 5 km of the GTP. For these four receptors, the degree of visual intrusion of the GTP and stack would be low to negligible. For all other receptor locations within the viewshed, the distance (>5 km) would entail that the visual intrusion factor and thus the visual impact of the GTP, stack and flare would be negligible.

Thus when the mitigating factors of distance of view and domination of existing views by the Majuba Power Station are taken into account, the overall visual impact of the GTP and stack on the receptors in the surrounding area is likely to be low.

Flaring from the GTP‘s stack could be associated with a visual intrusion factor, in spite of the distance. This would especially be the case at night, when in spite of the high degree of lighting associated with the Majuba Power Station, the flare would be visible in a night-time context. It is however understood that flaring will only be done as an emergency measure.

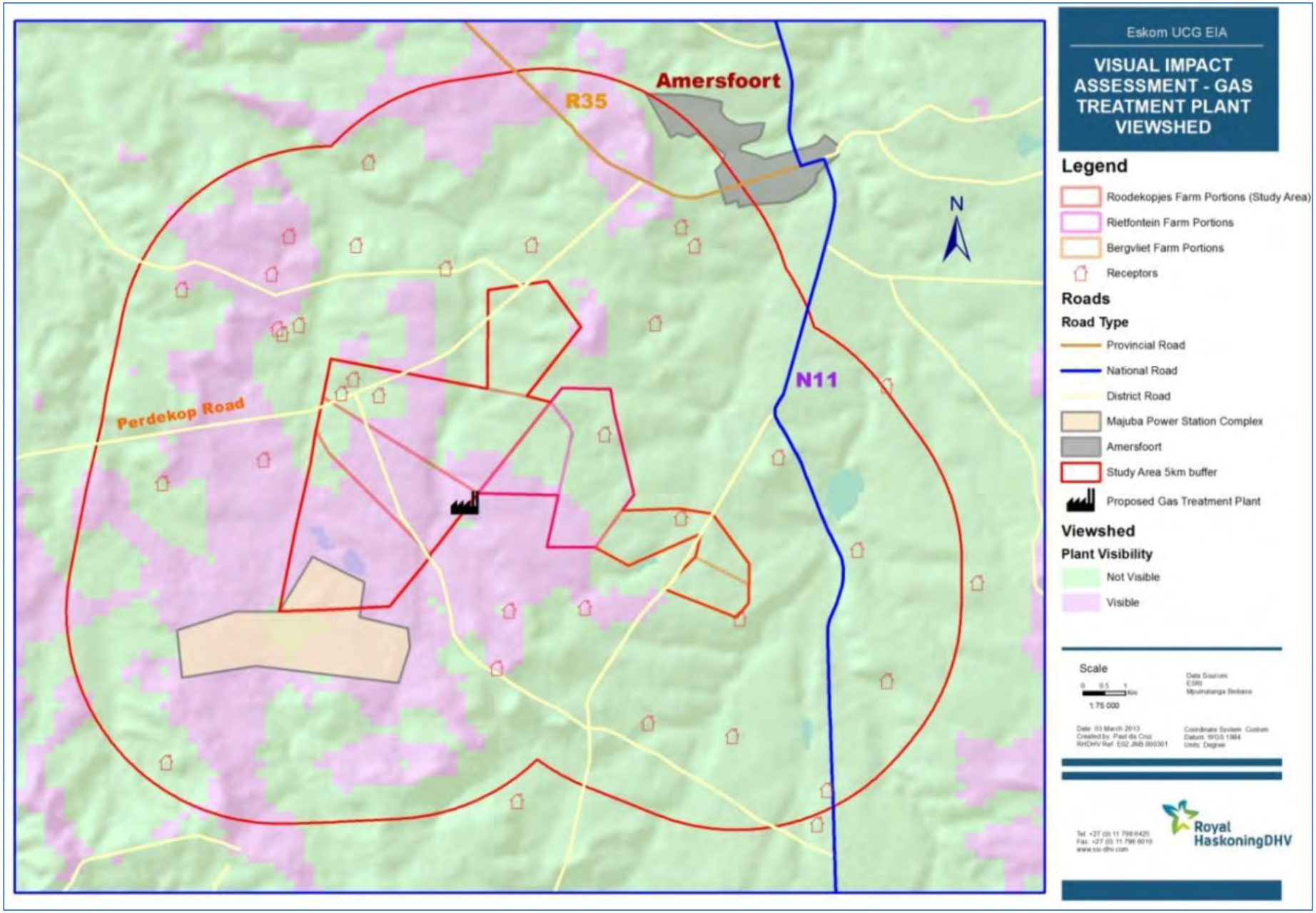


Figure 53: Viewshed of the Gas Treatment Plant's 9 m-high stack

6.12.4 Visual Impact Associated with the Gasifier Units

Gasifier units are proposed to be developed across the Roodekopjes site, the Pilot Plant Phase 1 unit is the first developed and has a total footprint with its associated infrastructure of approximately 50 ha with a maximum height of 2 m.

The viewer is presented with a view of a network of pipelines. As with the gas treatment plant discussed above, the degree of visual intrusion associated with gasifier units depends on a number of factors including the distance between the receptor locations and the gasifier, as well as on the topography of the area in which the gasifier is located that determines the area in which the gasifiers would be visible.

As with the gas treatment plant, many of the receptors would view the Pilot Plant gasifier in the same view that is dominated by the structures of the Majuba Power Station, thus already presenting a view of an industrialised context. In this context (a high VAC) the distant gasifier unit would be less likely to be perceived to be incongruous with the setting.

6.12.5 Visual Impact Associated with other UCG-related activities

6.12.5.1 Subsidence

The UCG process may cause the subsidence of areas of ground that are undermined, due to the collapse of the coal seam once it has been combusted. To date no subsidence has occurred.. It is expected that areas are likely to subside evenly, and thus there will be unlikely to be a marked impact on the micro-topography within undermined parcels of land. However a ~~"~~micro-escarpment" or gulley wall may form between areas subsiding and those not. This could form a visible scar or landscape feature in the environment as the level of subsidence is expected to be up to 0.75 m deep. This feature would be likely to create a linear band within a landscape that would be visible and prominent due to its linear nature, especially if it started to erode.

Insufficient information is available at this point to accurately determine how and where subsidence would affect the micro-topography of the site. Thus the location-specific visual impacts of subsidence are unable to be determined at this point. Should more detailed information relating to the impacts of subsidence become available, this will be able to be assessed in a further revision of this report.

It should be noted that the existing Pilot Plant Phase 1 is effectively a test area forming part of the ongoing research process to determine whether issues such as subsidence may become an issue when rolled out on a larger scale.

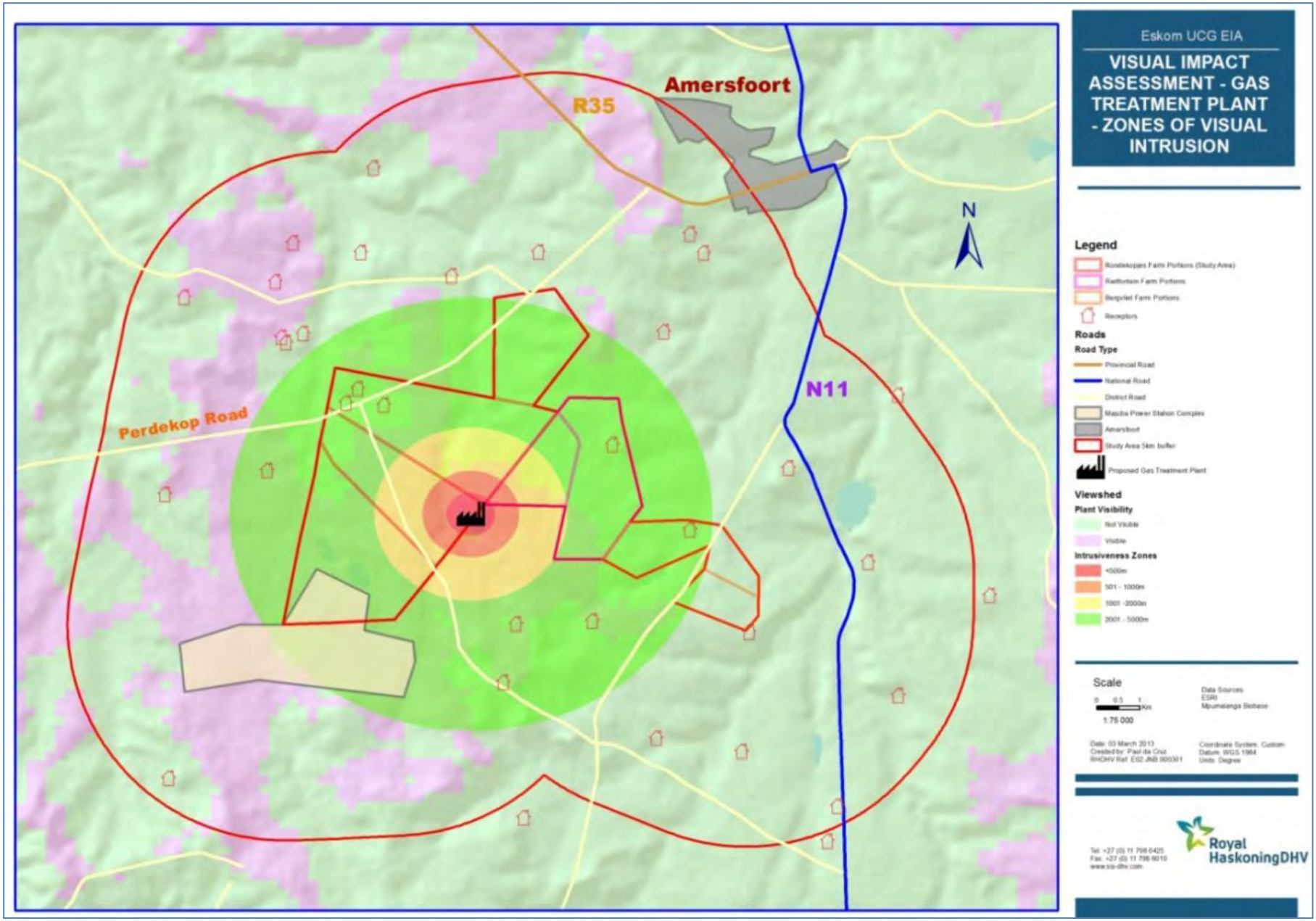


Figure 54: Location of receptors in relation to the distance bands from the gas treatment plant

6.12.5.2 Irrigation of land with effluent

One of the proposals being considered by the proponent would be to use effluent from the gas treatment plant to irrigate certain parcels of land on, and in the immediate vicinity of the Roodekopjes site. Areas to be irrigated would be planted with the grass species *Eragrostis curvula*, a widely cultivated grass. Irrigation is proposed to be undertaken by a vehicle that would dispense the effluent into the area under irrigation. If adopted, this process is unlikely to result in a visual impact, as the area under irrigation would retain a similar texture and colour to the natural grassland that currently occurs over most of the Roodekopjes site and immediately adjacent areas, and due to the absence of large-scale irrigation equipment. This alternative will only be considered in the parallel EIA process.

6.12.6 Recommendations

- Flaring should be prevented as much as possible, and be limited to daylight hours.

7 IMPACT ASSESSMENT

7.1 Methodology

The potential environmental impacts associated with the project will be evaluated according to its nature, extent, duration, intensity, probability and significance of the impacts, whereby:

Table 51: Environmental criteria

Environmental Criteria	Description
Nature	A brief written statement of the environmental aspect being impacted upon by a particular action or activity
Extent	The area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment phase of a project in terms of further defining the determined significance or intensity of an impact. For example, high at a local scale, but low at a regional scale
Duration	Indicates what the lifetime of the impact will be
Intensity	Describes whether an impact is destructive or benign
Probability	Describes the likelihood of an impact actually occurring
Cumulative	In relation to an activity, means the impact of an activity that in itself may not be significant but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area.

Table 52: Criteria to be used for the rating of impacts

Impact criteria	Description			
Extent	**National (4)** Whole of South Africa	**Regional (3)** Provincial and parts of neighbouring provinces	**Local (2)** Within a radius of 2 km of construction site	**Site (1)** Within construction site
Duration	**Permanent (4)** Mitigation either by man or natural proc ess will not occur in such a way or in such a time span that the impact can be considered transient	**Long-term (3)** Impact will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter. The only class of impact which will be non-transitory	**Medium-term (2)** Impact will last for period of construction phase, where after it will be entirely negated	**Short-term (1)** Impact will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase
Intensity	**Very High (4)** Natural, cultural and social functions and processes are altered to extent that they permanently cease	**High (3)** Natural, cultural and social functions and processes are altered to extent that they temporarily cease	**Moderate (2)** Affected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way	**Low (1)** Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected
Probability of occurrence	**Definite (4)** Impact will certainly occur	**Highly Probable (3)** Most likely that the impact will occur	**Possible (2)** Impact may occur	**Improbable (1)** Likelihood of the impact materialising is very low

Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

The significance rating, as given in **Table 54**, is calculated as:

Extent + Duration + Intensity + Probability

This formula gives a maximum value of 16 and a minimum value of 0 (zero). Note that a value of zero is only possible if no impact is triggered (either positive or negative).

Table 53: Significance rating of classified impacts

Impact rating	Description	
Neutral / negligible (0 to –2 points)	Impact is either positive or negligible as the change from the *status quo* is almost impossible to quantify.	
Low (–3 to –5)	Low impact has no permanent impact of significance. Mitigation measures are feasible and are readily instituted as part of a standing design, construction or operating procedure.	
Medium (–6 to –8)	Mitigation is possible with additional design and construction inputs.	
Medium-high (–9 to –11)	Mitigation is possible with additional design and construction inputs, but the alternatives need to be carefully considered for possible changes to reduce the risk to the site and wider environment.	
High (–12 to –14)	Design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. Effects of the impact will affect the broader environment.	
Very high (–15 to –16)	Permanent and important impacts. Design of the site must be affected. Intensive remediation will be needed during construction and/or operational phases. Any activity which results in a ~~"~~very high impact" is considered to be a fatal flaw.	
Status	Denotes the perceived effect of the impact on the affected area.	
Positive (+)	Beneficial impact.	
Negative (-)	Deleterious or adverse impact.	*Note that negative and neutral impacts are considered similarly as "negative" in significance.*
Neutral (/)	Impact is neither beneficial nor adverse.	

Note that no one factor is weighted over any other for this risk as given the nature of the application, the uncertainties inherent in this being a research project, and, the potential scale of impacts. That is, no one factor is deemed to be more important than any other.

~~"~~**Unmitigated**" is the taken as the *status quo* which is to a certain extent already mitigated. ~~"~~**Mitigated**" is taken as the best practice moving forward, that is, what in addition can be done to further reduce the risk while the pilot plant continues operation (if allowed). The values are not the extreme worst case as the site is being run to a high standard already with no significant contamination events to date.

As such the risk value does not change as much as would be encountered in a standard EIA where the preferred option is considered against the worst case scenario or an undeveloped *status quo* situation. Further, the nature of the surroundings is such that contamination events, should they occur, would be buffered to a certain extent.

The suitability and feasibility of all proposed mitigation measures will be included in the assessment of significant impacts. This will be achieved through the comparison of the significance of the impact before and after the proposed mitigation measure is implemented. Mitigation measures identified as necessary will be included in an EMPr.

The subsequent sections will provide a description of the potential impacts as identified by the specialists, EAP and through the public participation process as well as the assessment according the criteria described in **Table 52** and **Table 53**.

A point to note in terms of the phase description given in the impact tables hereafter – the term ~~"~~construction" is given for activities that may be ~~"~~actual construction activities", ~~"~~maintenance activities" and ~~"~~decommissioning activities" as these all have similar impacts.

Further note that many of the true construction activities have already occurred and as such are completed or significantly completed. The mitigation requirements thus remain in place as they will still need to be monitored and where required enhanced.

7.2 Infrastructure item-related impact consideration

As an overview the *status quo* impact of the various activities taking place currently on the site is presented in this section according to the specific activity. Thereafter in **Sections 0** to **7.17** the issues are considered by environmental factor.

Table 54: Significance rating of impacts by infrastructure item already constructed

Aspect	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Raw water dam **Impacts:** – Removal of soils and vegetation for establishment of the dam – Erosion due to exposed soils	Extent: Local (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Definite (-4) **Significance: Medium-high (-11)**	• Ensure that the operation of the dam is part of an endorsed water use license. • It is essential to have an adequately sized dam to contain raw water.	Extent: Site (-1) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Highly probable (-3) **Significance: Medium-high (-9)**
Condensate (process) water dam **Impacts:** – Removal of soils and vegetation for establishment of the dam – Erosion due to exposed soils – Incorrect design and construction of dam i.e. placement of dam in drainage line – Possible groundwater and soil contamination – Odour	Extent: Site (-3) Duration: Long-term (-3) Intensity: High (-3) Probability: Highly probable (-3) **Significance: High (-12)**	• Current condensate must be transferred to the new dam (once authorised) via the filter plant. Sludge must be removed and disposed of at a licensed hazardous waste disposal site. • Existing dam, lining and associated infrastructure must be dismantled, removed and disposed of at a licensed hazardous waste disposal site. • Soils excavated must be tested and if it is established that there is contamination, the soils should be disposed of properly by a reputable waste management company at a licensed hazardous waste disposal site. • Rehabilitation of the existing dam site: – Rehabilitate disturbed areas with natural vegetation. – Exposed areas must be rehabilitated immediately to prevent soil erosion. – Compile and implement environmental monitoring programme, the aim of which should be ensuring long-term success of rehabilitation and prevention of environmental degradation. Environmental monitoring should be conducted at least twice per year (i.e. Summer, Winter). – Ensure proper surface restoration and re-sloping in order to prevent erosion, taking cognisance of local contours and landscaping. – Exposed areas with slopes less than 1:3 should be rehabilitated with a grass mix that blends in with the surrounding vegetation. – The re-vegetated areas (where possible), should be temporarily fenced to prevent damage by grazing animals. – Re-vegetated areas showing inadequate surface coverage (less than 30% within eight (8) months after re-vegetation) should be prepared and re-vegetated from scratch.	Extent: Site (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Possible (-2) **Significance: Medium-high (-9)**

Aspect	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
		• Damage to re-vegetated areas shall be repaired promptly. **Re-purposing the condensate so that it becomes a by-product, rather than a waste which needs to be removed to Gauteng for treatment, will further reduce the risk.** **This will form part of the parallel EIA process and is NOT considered in terms of mitigation at this time.**	
Borrow pit **Impacts:** – Removal of soils for establishment of the dam – Loss of vegetation and faunal habitat – Erosion due to exposed soils – Alien invasive weed infestation – Visual – Safety	Extent: Site (-1) Duration: Permanent (-4) Intensity: Moderate (-2) Probability: Definite (-4) **Significance: Medium-high (-11)**	• Closure and rehabilitation of the borrow pit: – The borrow pit must be rehabilitated in a way that blends with the surrounding area and appears as a natural extension to the adjacent, undisturbed ground profile. – Even contours are created and no slopes steeper than 1:3 are created. – All material in and around the borrow pit, whether spoils, excess stockpiled material, material resulting from clearing and grubbing or excess overburden should be used for shaping or appropriately disposed of. – The level of compaction of areas disturbed by heavy-duty machinery should be addressed preferably prior to the spreading of topsoil by scarifying the ground surface wither by plough or mechanical ripper to a depth of approximately 150 mm to break down soil clods. – Approximately 50 to 100 mm of topsoil should be applied to the scarified borrow pit. – Before placing topsoil, all visible weeds should be removed. – On completion of the rehabilitation process, the borrow pit should drain properly and the run-off water should not cause erosion. Measures to prevent soil erosion include: appropriate shaping of the borrow pit; ensuring that slopes are no steeper than 1:3; stabilisation by re-vegetation and the application of chemical stabiliser. – The borrow pit should be free draining, in this way ponding will be minimised. – Exposed areas should be re-vegetated with a grass mix that blends in with the surrounding vegetation. – The re-vegetated areas (where possible), should be temporarily fenced to prevent damage by grazing animals. – Re-vegetated areas showing inadequate surface coverage (less than 30% within eight months after re-vegetation) should be prepared and re-vegetated from scratch. – Damage to re-vegetated areas shall be repaired promptly. – Any runnels or erosion channels developing after re-vegetation should be backfilled and consolidated and the areas restored to a proper stable condition.	Extent: Site (-1) Duration: Medium-term (-2) Intensity: Low (-1) Probability: Possible (-2) **Significance: Medium (-6)**

Aspect	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Gasifier Roads – including linked watercourse crossings **Potential impacts:** – Loss of riparian vegetation – Erosion of banks – Siltation – Flow modification – Water quality impairment	Extent: Local (-2) Duration: Permanent (-4) Intensity: High (-3) Probability: Definite (-4) **Significance: High (-14)**	• Road design at the watercourse crossing must incorporate a sufficient number and volume of culverts to allow flow within the watercourse to pass under the road in as natural a manner as possible; i.e. flow within wetlands should be kept as diffuse as possible where diffuse flow occurs. • Structures e.g. culverts must be inspected regularly for accumulation of debris and blockages - debris must be removed and damages must be repaired and reinforced immediately. • Stormwater management structures must be constructed, operated and maintained in a sustainable manner throughout the affected area and, should include but not be limited to the following: – Increased run-off because of vegetation clearance and/or soil compaction must be managed, and steps must be taken to ensure that stormwater does not lead to bank instability and excessive levels of silt entering the watercourse. – Stormwater must be diverted from the gasification area and roads and must be managed in such a manner so as to disperse run-off and to prevent concentrated stormwater flow (silt traps, barriers such as sand-bags). – The velocity of stormwater discharges must be attenuated and the banks of the watercourses protected. • Any impacted areas within the riparian zone should be rehabilitated, specifically to re-vegetate the area with suitable vegetation. • The re-vegetated areas (where possible), should be temporarily fenced to prevent damage by grazing animals. • Only appropriate indigenous riparian vegetation may be used for rehabilitation and re-vegetation within the disturbed area.	Extent: Local (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Definite (-4) **Significance: Medium-high (-11)**
Gas treatment plant **Impacts:** – Loss of vegetation – Groundwater and soil contamination through leaks – Release of fugitive emissions	Extent: Local (-2) Duration: Permanent (-4) Intensity: Moderate (-2) Probability: Highly probable (-3) **Significance: Medium-high (-11)**	• Implementation of inspection programs to maintain the mechanical integrity and operability of pressure vessels, tanks, piping systems, relief and vent valve systems, containment infrastructure, emergency shutdown systems, controls and pumps, and associated process equipment. • Regularly monitor fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapour detection equipment, and maintenance or replacement of components in a prioritized manner. • Regular groundwater monitoring programme. • Institute clean up protocol should there be a local leakage. • On-going raw gas transfer pressure measurement with pressure change alarm signal control.	Extent: Site (-1) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Highly probable (-3) **Significance: Medium-high (-9)**

Aspect	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Hazardous substance storage (e.g. diesel) **Impact:** – Spillage and contamination – Uncontrolled releases of hazardous materials to the environment or uncontrolled reactions that might result in fire or explosion	Extent: Local (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Definite (-4) **Significance: Medium-high (-11)**	• Implementing management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Appropriate secondary containment structures consist of berms or walls (bunds) capable of containing a minimum of the larger of either 110% of the largest tank or 25% percent of the combined tank volumes in the area, with above-ground tanks with a total storage volume equal or greater than 1,000 litres and will be made of impervious, chemically resistant material. • Fire prevention systems and secondary containment should be provided for storage facilities, where necessary or required by regulations, to prevent fires or the release of hazardous materials to the environment. • Exercise appropriate emergency preparedness programmes (plans, schedules, procedures and methods) for addressing environmental accidents, incidents and events such as the spillage of fuel. • Conducting periodic (e.g. daily or weekly) reconciliation of tank contents and inspection of visible portions of tanks and piping for leaks. • Periodic pressure testing should be undertaken. • The constraints of the SANS codes with respect to the aboveground tank storage requirements must be met.	Extent: Site (-1) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Possible (-2) **Significance: Medium (-8)**
Condensate water treatment plant **Impact:** – Groundwater and soil contamination through leaks – Functional integrity of the water treatment plant – unable to remove hydrocarbons	Extent: Local (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Highly probable (-4) **Significance: Medium-high (-10)**	• Dismantle current 15,000 Nm^3/hr water treatment plant and replace with a pilot activated carbon filtration system. • Ensure that the decommissioning of the current water treatment plant and the new activated carbon filtration system have the necessary environmental approvals. • All plant components to be disposed of at a licensed hazardous waste disposal facility. • Rehabilitation of the existing water treatment plant site: – Rehabilitate disturbed areas with natural vegetation. – Exposed areas must be rehabilitated immediately to prevent soil erosion. – Ensure proper surface restoration and re-sloping in order to prevent erosion, taking cognisance of local contours and landscaping. – Damage to re-vegetated areas shall be repaired promptly.	Extent: Site (-1) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Possible (-2) **Significance: Medium (-8)**

7.3 Geology

Table 55: Significance rating of geological impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Drilling of wells to coal seam depth	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** High (-3) **Probability:** Definite (-4) **Significance: Medium-high (-9)**	• On-going development of mining methodology / plan describing specifications (i.e. depth, size, spacing), sequencing and well location. • Appointment of a qualified drilling contractor. • All wells must be sealed all the way into the coal seam and grouted with cement. • A lot of care should be taken during well construction to ensure that there are no air voids and no contacts points with the upper aquifer. • All drill cuttings should be disposed off at a licensed landfill site.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Operations	High concentration gas accumulation in gasification chamber leading to underground explosions	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Gasification process linked to specially designed process software to ensure early detection of upset / emergency conditions underground. • During operation gasification can be controlled and the flow of air into the well can be stopped thereby stopping the gasification process.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Medium (-6)**
	Surface subsidence as a result of undermining the entire farm.	**Extent:** Site (-1) **Duration:** Permanent (-4) **Intensity:** Very High (-4) **Probability:** Definite (-4) **Significance: High (-13)**	No mitigation proposed other than for subsidence and the related impact on wetland systems, surface water resources, groundwater inputs into wetlands, and, surface water resources (refer to: **Hydrogeology**, **Hydrology, Wetlands**)	**No direct mitigation**
	Goafing (gasification chamber roof collapse)	**Extent:** Site (-1) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***No mitigation proposed.***	**No mitigation**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Decommissioning	Decommissioning of injection wells and production wells.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** High (-3) **Probability:** Highly probable (-3) **Significance: Medium-high (-8)**	• Upon decommissioning, some wells are kept open with valves and flanges for post-gasification monitoring; others are sealed with concrete and capped to ensure that they do not pose a risk to people and animals post-gasification.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Cumulative	Groundwater resources contamination through shearing of geological buffer layers.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Very High (-4) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	• UCG technology is conducted such that the gasification pressure is always slightly less than the hydrostatic pressure of the fluid in the coal seam - creating a pressure gradient directed towards the gasifier. Thus no flow from the gasifier into the surroundings is allowed, preventing product loss and contamination of underground water resources. • Thorough knowledge of the existing aquifers in the vicinity of the underground gasifier and careful monitoring of the hydrostatic pressure in the aquifers during the UCG operations must form an important groundwater protection strategy.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-8)**

7.4 Hydrogeology

Table 56: Significance rating of hydro-geological impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Shallow groundwater contamination: • Spillage of fuels, lubricants and other chemicals. • Construction equipment, vehicles, workshop and wash bay areas a likely source of pollution as a non-point source. • Lack of provision of ablutions may lead to creation of informal ablutions.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Chemicals to be stored in bunded areas. • Clean-up of spills as soon as they occur and maintain an incident register. • Adequate provision of ablutions for construction employees. • Groundwater monitoring to confirm any impacts.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**
Operations	Potential lowering of the shallow groundwater level in farmers' boreholes.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Improbable (-1) **Significance: Medium (-8)**	• B5 dolerite sill acts as a hydraulic barrier, thus no impact on shallow groundwater levels is expected. • Depends on rock stability above the gasifier / cavity roof which determines if goafing and/or subsidence will occur. • Major mitigation measure is to develop the gasifier panels such that goafing / subsidence do not occur.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Medium (-6)**
	Contamination of the shallow groundwater quality.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Improbable (-1) **Significance: Medium (-8)**	• B5 dolerite sill acts as a hydraulic barrier, thus no impact on shallow groundwater levels is expected. • Depends on rock stability above the gasifier / cavity roof which determines if goafing and/or subsidence will occur. • Major mitigation measure is to develop the gasifier panels such that goafing / subsidence do not occur.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Medium (-6)**
	Failure of production borehole casings.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	• Ensure casing and grouting specifications are adhered to. • On-going groundwater monitoring to identify potential impacts. • Operation pressure and temperature monitoring is critical in identifying potential casing failures.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-8)**
	Impact on the coal seam water level – the gasification process consumes groundwater and an impact on the coal seam water level is expected.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Highly probable (-3) **Significance: Medium-high (-9)**	• Coal seam groundwater is not used and is not deemed fit for consumption. • 1 m drawdown impact is expected approximately 1.5 km within coal seam water. • No mitigation measures are recommended.	**No mitigation**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	The gasification process may impact on the quality of the coal seam groundwater.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**	Mitigation measures during closure may include flushing of the gasifier and/or treatment of the gasifier water.	**Unknown mitigation – ongoing investigation as to the best solutions**
	Overflow from process water dam causing an impact on the shallow groundwater quality.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Long-term solution is to construct a process water dam with sufficient capacity to cater for down-time of the water treatment plant. • Ensure existing condensate dam is kept with sufficient capacity to cater for expected amounts of contaminated water – this includes periodic drainage and disposal of condensate to a registered disposal site • Other mitigation measures require additional activities such as the future dam not being in the 1:50 flood line. These cannot be implemented now.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**
	Leaks of untreated water from pipelines may occur and impact on the shallow groundwater quality.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**	Any leaks should be fixed immediately and areas rehabilitated as needed.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**
Decommissioning	Impact on the coal seam water level – after the gasification process has shut down the impact on the coal seam water level will remain during the water level recovery period.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Highly probable (-3) **Significance: Medium-high (-9)**	• Coal seam groundwater is not used and is not deemed fit for consumption. • 1 m drawdown impact is expected approximately 1.5 km within the coal seam water. • No mitigation measures are recommended. • According to numerical modelling the groundwater levels should recover in the gasifier area within 20 years after production.	**No mitigation**
	The gasification process may impact on the quality of the coal seam groundwater that will remain after closure.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**	Mitigation measures during closure may include flushing of the gasifier and/or treatment of the gasifier water.	**Unknown mitigation – ongoing investigation as to the best solutions**

7.5 Hydrology

Table 57: Significance rating of hydrological impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Run-off: • Spillage of fuels, lubricants, other chemicals. • Inadequate storm water management around the site. • Dumping of construction material (e.g. fill or excavated material) into / close to surface water features thus impacting thereon. • Construction-related activities (e.g. cement batching). • Construction equipment, vehicles and workshop areas as likely source of pollution (non-point). • Lack of provision of ablutions leading to informal ablutions'.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Bunded areas should be used to store chemicals. • Clean-up of spills as soon as they occur. • Keep construction activities away from the Geelklipspruit. • Adequate provision of ablutions for construction employees.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**
	Construction of pipelines: • Pollution of water within wetlands by construction activities. • Incorrect re-instatement of wetland vegetation – leading to exposure / erosion of wetland soils, thus downstream sedimentation. • The compaction of wetland soils through the use of machinery in the wetland.	**Extent:** Local (-2) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-8)**	• Construction phase to include strict rules regarding wetland areas. • Rehabilitation Plan linked to all construction activities.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**
Operations	Run-off from dirty areas such as: • Workshop areas; • Chemical storage areas; and • Access roads.	**Extent:** Local (-1) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Adequate site stormwater management to comply with GNR 704. • Currently channels carrying water from dirty areas are not diverted into a pollution control dam but water quality is monitored at the release point into the watercourse. Not best practice (as per Stormwater Management Plan (**Appendix P (sub-appendix B)**), stormwater management plan needs to be re-addressed – however such activities would trigger new listed activities in their own right and thus	**Extent:** Local (-1) **Duration:** Medium-term (-2) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
			cannot be considered within this application. • Chemical storage areas to be bunded so that if a spill occurs the chemical will be contained.	
	• Discharge of treated effluent from existing wastewater treatment works, treats ±10m^3/d. • Discharge of poor quality effluent to a small stream (e.g. Geelklipspruit) may cause pollution to downstream water users. However, in line with Eskom's no discharge policy, no treated wastewater is expected to be discharged from the plant and associated infrastructure into the adjacent environment unless a failure of the WWTW occurs.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Low (-4)**	• Wastewater treatment works is extant so no further mitigation is necessary. • On-going operational and maintenance resources to ensure that the plant operates optimally. • Impact significance for a potential spill in terms of both quantity and quality remains low.	**Unchanged**
	Overflow from process water dam.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	It is essential to have an adequately sized dam to contain the contaminated water. In addition, the dam should not be in the 1:50 flood line. These are however future interventions as they would constitute new listed activities and will be considered in the parallel EIAR.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**
	Leaks from pipelines – leaks of untreated water from pipelines may occur.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**	Any leaks should be fixed immediately and areas rehabilitated as needed.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
	Undermining – potential subsidence of ground in areas above mining operations. Worst-case scenario, subsidence of ground at surface up to 75 cm. Extent of subsidence is being monitored. Note that policy of non-undermining of wetland areas and associated buffer zones is taken into account this may result in localised variations in micro-topography in certain parts of wetland catchments.	**Extent:** Local (-2) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	***No mitigation proposed as little can be done if planning has failed and the subsidence has occurred.***	**Unchanged**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Subsidence could conceivably result in a ‗ridge' / embankment forming within part of the wetland's immediate catchment whereby the ‗upslope' areas could be lower than the downslope areas, thus significantly disrupt overland flow of water into wetlands. Subsidence may also conceivably have an impact discharge of shallow groundwater to hillslope seepage wetlands.			
Decommissioning	Pollution of water resources due to infrastructure decommissioning: • Infrastructure decommissioning (e.g. workshop buildings, plant area) containing surface water pollutants (e.g. fuel / hydrocarbon storage tanks, wastewater storage / condensate dams). • The risk of this impact depends on the proximity of infrastructure to surface water receptors, and to links between groundwater and surface water resources in the case of seepage of pollutants into the ground that may pollute groundwater. • Residual impacts of mining activities such as development of soil erosion or improperly maintained roads may result in secondary impacts on water resources through the extension of erosion into the wetland or other surface water resources resulting in silt deposition.	**Extent:** Local (-2) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-8)**	Proper post-operation rehabilitation, removal and disposal of any material that could cause pollution of water resources through seepage or stormwater run-off is important.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**

7.6 Freshwater Ecology

Table 58: Significance rating of impacts of freshwater ecology

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Water Quality Impairment • Direct – Construction equipment, vehicles and material (direct source). • Indirect / non-point source – Run-off from building materials (e.g. cement) into watercourses during construction / maintenance of hard surface development structures / bridges.	**Extent:** Regional (-3) **Duration:** Medium-term (-2) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Compliance with EMPr, implementation of which is monitored by an on-site Environmental Officer. • Run-off prevention from directly entering watercourse catchments by implementing features such as the use of silt traps and other measures. • On-going stormwater channel cleaning program implemented as standard operating procedure to avoid any debris collection in channels – minimum sediment should be removed from channels during the dry season and at least once during the wet season. • Construction and maintenance to be scheduled to drier months when possible.	**Extent:** Local (-2) **Duration:** Medium-term (-2) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**
	Loss of riparian habitat and bed / bank modification.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium (-8)**	• Minimise impact on riparian zone, particularly in channel margins / banks. • Impacted areas re-vegetated as soon as it occurs. Soil embankment exposure due to run-of-river erosion potential and formation of potential freshets. • Impacted areas within riparian zone should be rehabilitated, specifically re-vegetating. • Desirable to maintain and re-establish 30 m buffer strip to protect impacts on the river. • Rehabilitate with indigenous vegetation. • Undertake maintenance measure and implement anti-erosion structural upgrades.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
	Flow modification.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium (-8)**	• Small section of the rivers / drainage lines impacted by flow modification, recommended that development areas form part of a stormwater master plan / stormwater management plan to control all on site stormwater related impacts (i.e. construction and maintenance).	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Operations	Water quality impairment.	**Extent:** Regional (-3) **Duration:** Medium-term (-2) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• During operation water quality must be continually monitored as part of the proposed development risk response management (early detection system). • Implementation of the EMPr. • Hazardous waste handling must be in line with the EMPr mitigation and monitoring measures.	**Extent:** Regional (-3) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
Decommissioning	***Same as construction phase impacts relating to water quality impairment.***	**Extent:** Regional (-3) **Duration:** Medium-term (-2) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***Refer to construction phase specific mitigation measures above.***	**Extent:** Local (-2) **Duration:** Medium-term (-2) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**
Cumulative	Erosion – surface water features studied are largely homogenous, but very sensitive in terms their channel and bank stability.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Highly Probable (-3) **Significance: Medium-high (-11)**	Erosion management plan should be implemented and complied with during all phases of development.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**
	Plant construction (hard surfaces).	**Extent:** Regional (-3) **Duration:** Medium-term (-2) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Compliance with construction EMPr. • Monitoring implementation by an Environmental Control Officer (ECO).	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-6)**

7.7 Wetlands

Table 59: Significance rating of impacts to wetlands

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	• Irresponsible construction practices leading to wetland and river pollution (e.g. faecal contamination, hydrocarbons). • Poor stormwater management leading to siltation of surface waters. • Temporary accesses across wetlands / rivers causing hydrological and morphological impacts and degradation of the resource quality.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	• Construction guided by Eskom guidelines for construction. • Construction monitored by an ECO according to stipulations of the EMPr. • No batching or chemical / fuel storage areas to be located within any surface water feature or associated buffer. • Construction stormwater management plan to prevent silt ingress into surface water features. • No temporary construction accesses constructed through any surface water feature. • No machinery to enter any wetland unless authorised by the ECO.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Operations	Gasification: • Gasification activities leading to subsidence of parts of wetland catchments due to undermining, significantly impacting surface and sub-surface (including groundwater) flows into wetlands. • Pollutant spills (e.g. hydrocarbons) due to leakages from equipment.	**Extent:** Local (-2) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Highly probable (-3) **Significance: High (-12)**	• Gasification layout should be designed so that subsidence is greatly limited or does not occur. • If not possible, undermining of entire wetland unit to ensure even subsidence across catchment. • Leakage detection systems on storage tanks. • Leakage rehabilitation and clean up procedures to be put in place.	**Extent:** Site (-1) **Duration:** Permanent (-4) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Linear Infrastructure: • Roads constructed across wetlands adversely affect hydrology and wetland morphology, primarily by channelization. • Access for machinery for pipeline and road maintenance damaging wetlands. • Pipeline leaks / failures within wetlands or their catchments polluting wetlands with hydrocarbons.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	• Avoid routing linear infrastructure through wetlands, rather run it along interfluves. • Strict control of machinery access into wetlands. • Access roads crossing wetlands should cross at their narrowest points, and perpendicular to flow. • Leakage detection systems to be implemented. Leakage rehabilitation and clean up procedures to be put in place.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Removal of cattle.	**Extent:** Site (+1) **Duration:** Long-term (+3) **Intensity:** Moderate (+2) **Probability:** Highly probable (+3) **Significance: Medium (+9)**	No mitigation proposed. Removal of cattle during operational life-time is likely to be a positive impact as it will give the wetlands a chance to naturally recover and no further degradation would be likely to occur.	**Unchanged – mitigation not required**
Decommissioning	• Removal of pipelines from wetland (crossings) resulting in spillage of pipeline contents (hydrocarbons) into wetlands, thus wetland pollution. • Entrance of machinery damaging wetlands, affecting resource quality. • Irresponsible and uncontrolled decommissioning (construction) practices causing wetland pollution.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	• Decommissioning to be guided by Eskom guidelines for construction / decommissioning. • Decommissioning to be monitored by an ECO according to the stipulations of the EMPr. • No temporary accesses through any surface water feature and no machinery to enter any wetland unless authorised by the ECO.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Low (-6)**
Cumulative	• Impacts on individual wetlands could result in an important cumulative impact on respective catchments (e.g. Skulpspruit and Witbankspruit catchments). • Pollutants released into numerous wetlands through activities could result in downstream impacts. • Subsidence in a number of catchments could result in cumulative levels of wetland (hydrological) transformation and could result in downstream hydrological impacts.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***Refer to activity / phase specific mitigation measures above.***	***As per individual items above***

7.8 Soils and Agricultural Potential

Table 60: Significance rating of impacts to soils and agricultural potential

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Drilling of holes and associated vehicle movement.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Definite (-4) **Significance: Medium (-8)**	• Vehicle movement restricted to a distinct grid to prevent degradation of any additional land or parts of land. • Vehicle movement restricted to absolute minimum required for mining exercise. Unnecessary movement of vehicles will increase degradation leading to an increased erosion risk. • Drill rigs should remain stationary for as long a time as possible without unnecessary movement. • Grass bedding can be considered for under the drill rig tyres to prevent sinking into wet soils during the rainy season.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
	Construction of manifold system, pipes and other infrastructure.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Definite (-4) **Significance: Medium (-8)**	• Vehicle movement restricted to a distinct grid to prevent degradation of any additional land or parts of land. • Vehicle movement restricted to absolute minimum required for mining exercise. Unnecessary movement of vehicles will increase degradation leading to an increased erosion risk.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
	Vehicles operation on site – spillage of lubricants and petroleum products.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-6)**	• Vehicles and machinery properly maintained to keep oil and diesel leaks in check. • Depending on nature / extent of a spill, contaminated soil must be either excavated or treated on-site. • Excavation of contaminated soil should use appropriate tools / machinery, and placed into storage containers until treated or disposed of at a licensed hazardous landfill site.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Operation	Operation and gas extraction.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Definite (-4) **Significance: Medium-high (-10)**	• Vehicle movement restricted to a distinct grid to prevent degradation of any additional land or parts of land. • Vehicle movement restricted to absolute minimum required for mining exercise. Unnecessary movement of vehicles will increase degradation leading to an increased erosion risk.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**
	Vehicles operation on site – spillage of lubricants and petroleum products.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-6)**	• Vehicles and machinery properly maintained to keep oil and diesel leaks in check. • Depending on nature / extent of a spill, contaminated soil must be either excavated or treated on-site. • Excavation of contaminated soil should use appropriate tools / machinery, and placed into storage containers until treated or disposed of at a licensed hazardous landfill site.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Decommissioning	• Capping and sealing of boreholes • Removal of manifold system and pipes • Rehabilitation of access roads and drill areas	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Highly probable (-3) **Significance: Medium (-7)**	• Vehicle movement restricted to a distinct grid in order to prevent degradation of any additional land or parts of land. • Vehicle movement restricted to an absolute minimum required for decommissioning. Unnecessary movement of vehicles will increase degradation leading to an increased erosion risk. • Boreholes should be rehabilitated once all infrastructure has been removed. Soil erosion mitigation measures should be implemented on each of the borehole sites to ensure minimal land degradation once mining has ceased.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Cumulative	Impact of mining on agricultural potential and food security.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Definite (-4) **Significance: Medium-high (-9)**	***None possible unless mining does not continue. Limit extent of impact as far as possible.***	**No impact if mining does not continue**
	Impact of mining on soils.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Definite (-4) **Significance: Medium-high (-11)**	***None possible unless mining does not continue. Limit extent of impact as far as possible.***	**No impact if mining does not continue**

7.9 Biodiversity

Results of the floristic and faunal investigations were incorporated in order to present an overview of the impacts on the ecological environment. Results indicate the ~~"M~~edium-low" or ~~"L~~ow" ecological sensitivities of the following areas:

- Agricultural Fields;
- Degraded Grassland;
- Exotic Stands; and
- Transformed Areas.

The likelihood that sensitive biological attributes might occur in these parts of the study area is considered low and the likely impacts resulting from the proposed development on biological attributes within these areas are considered insignificant. These areas are therefore excluded from the impact assessment. The implementation of generic mitigation measures are considered sufficient in limiting any significant impacts.

Results of the ecological assessment indicate ~~"M~~edium" or higher ecological sensitivities of the following areas and are assessed below:

- Moist Grassland;
- Natural Grasslands; and
- Wetland Habitat.

Note that the mining type for this S24G process is limited to ~~"u~~ndermine partial" as this is the status of what has occurred to date.

7.9.1 *Moist Grassland*

Table 61: Significance rating of impacts to biodiversity – moist grassland vegetation type

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Destruction of conservation important flora taxa (i.e. threatened species) - Presence of Red Data flora species within the study area was confirmed during site investigations.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** Very High (-4) **Probability:** Highly probable (-3) **Significance: Very High (-14)**	• Limit construction, maintenance and inspection activities to dry periods to curb erosion occurrence / augmentation in areas conducive to soil erosion (e.g. destabilizing of substrate in areas of high slopes, riparian zones) • Demarcate construction areas to control movement of personnel, vehicles and provide boundaries for construction sites. • Disturbance of vegetation limited only to construction areas. • Removal or picking of any protected plants not be permitted and no horticultural specimens shall be removed, damaged or tampered with unless agreed to by the ECO. • Limit construction, maintenance and inspection activities to dry periods when Red Data species are most likely to be absent or hibernating, limiting potential impacts.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Direct impact on conservation important fauna species - The presence of Red Data fauna species was confirmed during the site investigations.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** Very High (-4) **Probability:** Highly probable (-3) **Significance: Very High (-14)**	• Implement a relocation plan for the location and removal of Sungazer Lizards, but only from sites that will be directly affected. Individuals present nearby activity sites should be conserved in situ. • Limit construction, maintenance and inspection activities to dry periods when Red Data species of the area are most likely to be absent or hibernating, limiting potential impacts.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Destruction of sensitive / pristine habitat types – extensive parts of the study area are regarded highly sensitive and are highly likely to be occupied by a diverse species composition as well as flora and fauna species of conservation importance.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Highly probable (-3) **Significance: Very High (-13)**	• Demarcate construction areas in order to control movement of personnel, vehicles, providing boundaries for construction sites in order to limit spread of impacts. • Disturbance of vegetation must be limited only to areas of construction. • Limit construction, maintenance and inspection activities to dry periods to curb occurrence / augmentation of erosion in areas conducive to soil erosion (i.e. destabilizing of substrate in areas of high slopes, riparian zones). • Limit construction, maintenance and inspection activities to dry periods when Red Data species are most likely to be absent or hibernating, limiting potential impacts.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Direct impacts on common fauna species.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Highly probable (-3) **Significance: Medium-high (-10)**	• No animal may be hunted, trapped or killed for any purpose whatsoever. • In the event that animals are present that may pose a risk to human safety (e.g. snakes, scorpions), a suitable animal handler must be requested to remove the animal in an environmentally responsible manner. • Demarcate construction areas to control movement of personnel, vehicles and provide boundaries for construction sites in order to limit impacts.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Floristic species changes subsequent to development – Construction will result in alteration of vegetation in parts of the study area and it is likely that current vegetation will become infested with weeds / invasive species.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Highly probable (-3) **Significance: Medium-high (-10)**	• Establishment and regrowth of invasive / alien vegetation controlled after removal of grass. • All declared aliens must be identified and managed in accordance with Conservation of Agricultural Resources Act (CARA, Act No. 43 of 1983). • Weed control methods should be confirmed with the Eskom Environmental Advisor to prevent undesirable secondary impacts. • Monitoring potential spread of declared weeds / invasive alien vegetation to neighbouring land and protecting agricultural resources and soil conservation works, are regulated by CARA and should be addressed on a continual basis.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Faunal interactions with structures, servitudes and personnel – Nature of proposed development is expected to result in indirect impacts on movement patterns of fauna species in some parts. In addition, direct interaction of fauna species with infrastructure is likely to occur.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	• No animal may be hunted, trapped or killed for any purpose whatsoever. • In the event that animals are present that may pose a risk to human safety, a suitable animal handler must be requested to remove the animal in an environmentally responsible manner.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**
	Surrounding habitats / species – Indirect nature of this impact dictates that potential impacts spreading from the proposed development into bordering areas is likely to affect natural habitat adversely.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	• Establishment and regrowth of invasive /alien vegetation must be controlled after removal of grass. • All declared aliens must be identified and managed in accordance with CARA. • Weed control methods should be confirmed with the Eskom Environmental Advisor to prevent any undesirable secondary impacts. Monitoring the potential spread of declared weeds and invasive alien vegetation to neighbouring land and	**Extent:** Regional (-3) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
			protecting the agricultural resources and soil conservation works are regulated by CARA and should be addressed on a continual basis.	
Cumulative	Impact on SA's conservation obligations and targets – loss of parts of Endangered and Vulnerable grassland vegetation types is expected to result in a limited, but nonetheless important, indirect impact on the conservation status of the regional vegetation types.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Improbable (-1) **Significance: Medium-high (-11)**	Limit loss of endangered (Sowetan Highveld Grassland) and vulnerable grassland vegetation (Amersfoort Clay Highveld Grassland).	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Medium (-8)**
	Increase in local and regional fragmentation / isolation of habitat.	**Extent:** Local (-2) **Duration:** Permanent (-4) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Utilise existing causal factors of habitat fragmentations. • Place new infrastructure adjacent to existing infrastructure e.g. pipelines.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Increase in environmental degradation.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***No mitigation proposed***.	**Unchanged**

7.9.2 *Natural Grassland*

Table 62: Significance rating of impacts to biodiversity – natural grassland vegetation type

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Destruction of conservation important flora taxa.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** Very High (-4) **Probability:** Highly probable (-3) **Significance: Very High (-14)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Direct impact on conservation important fauna species.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** Very High (-4) **Probability:** Highly probable (-3) **Significance: Very High (-14)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Destruction of sensitive / pristine habitat types.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Direct impacts on common fauna species.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**
	Floristic species changes subsequent to development.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Faunal interactions with structures, servitudes and personnel.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**
	Surrounding habitats / species.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Regional (-3) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
Cumulative	Impact on SA's conservation obligations and targets.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Improbable (-1) **Significance: Medium-high (-11)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Medium (-8)**
	Increase in local and regional fragmentation / isolation of habitat.	**Extent:** Local (-2) **Duration:** Permanent (-4) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**
	Increase in environmental degradation.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**No change**

7.9.3 *Wetland / Riparian Habitat*

Table 63: Significance rating of impacts to biodiversity – wetland / riparian vegetation type

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Destruction of conservation important flora taxa.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** Very High (-4) **Probability:** Highly probable (-3) **Significance: Very High (-14)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Direct impact on conservation important fauna species.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** Very High (-4) **Probability:** Highly probable (-3) **Significance: Very High (-14)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Destruction of sensitive / pristine habitat types.	**Extent:** Regional (-3) **Duration:** Definite (-4) **Intensity:** Very High (-4) **Probability:** Highly probable (-3) **Significance: Very High (-14)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Direct impacts on common fauna species.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**
	Floristic species changes subsequent to development.	**Extent:** Local (-3) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Faunal interactions with structures, servitudes and personnel.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Surrounding habitats/species.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
Cumulative	Impact on SA's conservation obligations and targets.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Highly probable (-3) **Significance: Very High (-13)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**
	Increase in local and regional fragmentation / isolation of habitat.	**Extent:** Regional (-3) **Duration:** Permanent (-4) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Increase in environmental degradation.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***Refer to mitigation measures proposed in the preceding table for the Moist Grassland habitat type.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**

7.9.4 Partial Undermining

Table 64: Significance rating of impacts to biodiversity – from partial undermining on all vegetation types

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Destruction of conservation important flora taxa.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Direct impact on conservation important fauna species.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Very High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Destruction of sensitive/pristine habitat types.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-11)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**
	Direct impacts on common fauna species.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Floristic species changes subsequent to development.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Faunal interactions with structures, servitudes and personnel.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Highly probable (-3) **Significance: Medium-high (-10)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Surrounding habitats/species.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
Cumulative	Impact on SA's conservation obligations and targets.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Increase in local and regional fragmentation/ isolation of habitat.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	Increase in environmental degradation.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**	***Refer to the mitigation measures indicated in the preceding tables as well as the EMPr.***	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**

7.10 Waste

Table 65: Significance rating of waste impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Contamination of the surface and site with general and hazardous waste. General waste produced on site includes: • Office waste (e.g. food waste, paper, plastic); • Operational waste (clean steel, wood, glass); and • General domestic waste (food, cardboards, paper, bottles, tins). Hazardous waste produced on site includes: • Waste sludge; • Spent activated carbon; • Oil and other lubricants, diesel, paints, solvent; • Containers that contained chemicals, oils or greases; and • Equipment, steel, other material (rags), soils, gravel and water contaminated by hazardous substances (oil, fuel, grease, chemicals or bitumen).	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** High (-3) **Probability:** Highly probable (-3) **Significance: Medium-high (-9)**	• Adequate number of general waste receptacles must be arranged around the site to collect all domestic refuse, and to minimise littering. • Bins should be clearly marked and lined for efficient control and safe disposal of waste. • Different waste bins according to waste streams must be provided to ensure correct waste separation. • A fenced area must be allocated for waste sorting and disposal on the site. • General waste produced on site collected in skips for disposal at local municipal waste site. • Hazardous waste may not be mixed / combined with general waste. • Under no circumstances is waste to be burnt / buried on site. • Waste bins to be cleaned out on a regular basis to prevent any windblown waste and/or visual disturbance. • General waste must be removed from site at regular intervals and disposed of suitable waste receptacle. • Hazardous waste is to be disposed at a Permitted Hazardous Waste Landfill Site – the waste manifest for each batch based disposal must be recorded. • Hazardous waste bins must be clearly marked, stored in a contained area (or have a drip tray) and covered (stored under a roof or container with a lid). • A hazardous waste disposal certificate must be obtained from the waste removal company as evidence of correct disposal. • In the case of spill of hydrocarbons, chemicals or bitumen, spill to be contained and cleaned up and the material with contaminated soil collected and disposed of as hazardous waste to minimize pollution risk.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Operations	Leakage of combustion condensate onto land along pipeline route.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Implement operation inspection protocol of gasfield pipe network. • Regular groundwater monitoring programme. • Institute clean up protocol should there be a local leakage. • On-going raw gas transfer pressure measurement with pressure change alarm signal control.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**
	Untreated water discharge into environment.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Process water dam represents a safety feature should there be a failure with the treatment plant. • Water treatment plant to have a proactive service and maintenance plan in place to ensure high availability. • Contaminated wastewater including hydrocarbon contaminated water must not enter any watercourse and must be managed to ensure that the existing water resources on and off site are not polluted. • Institute clean up protocol should there be accidental release of untreated water.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium-high (-9)**
	UCG condensate treatment and proposed handling –UCG condensate would have to be treated such that it can be considered for reuse, discharge into the environment or irrigation.	**Extent:** Regional (-3) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Highly probable (-3) **Significance: High (-12)**	• Contaminated wastewater including hydrocarbon contaminated water must not enter any watercourse and must be managed by the site manager to ensure that the existing water resources on and off site are not polluted. • Continue sampling and analysis of surface water quality in the targeted application area, including upstream and downstream. • Continue sampling and analysis of the treated condensate stream for the target range of pollutants and water quality parameters. • Material Safety Data Sheet (MSDS) for the condensate be readily available. MSDSs should include information pertaining to environmental impacts and measures to minimise and mitigate against any potential environmental impacts which may result from a spill. • On-going monitoring of inputs and outputs of the treatment plant. Monthly reports on removal efficiencies of the pollutants of concern such as phenol and PAH.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-8)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Leakage of hydrocarbons in the gas treatment plant.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Storm and process water should be separated by design and operating protocols. • Process water shall be directed to the water treatment plant. • All major incidents shall be reported and a root cause analysis undertaken. • Preventative measures shall be instituted to avoid potential hydrocarbon spillages.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**
	Improper disposal of admin-based waste water, brine, solid sludge and particulates and spent activated carbon.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Contaminated wastewater (i.e. with hydrocarbons) must not enter any watercourse and must be managed by the site manager to ensure that the existing water resources on and off site are not polluted by the development. • Measure volume of sludge removed from site and maintain a waste manifest in terms of its ultimate disposal. S sludge shall be analysed monthly for pH, total solids, organics, ammonia and ash content. • Measure volume of brine removed from site and maintain a waste manifest in terms of its disposal. • Maintain a log of solids removed and monitor regularly the qualitative parameters in the solids. Waste manifest for solids to be documented. • Waste manifest for activated carbon to be documented.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Decommissioning	Same as those wastes produced during construction.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** High (-3) **Probability:** Highly probable (-3) **Significance: Medium-high (-9)**	***Refer to mitigation measures included for waste impacts during construction as well as the EMPr.***	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
	Ingress of upper groundwater into combustion void with consequent build-up of contaminants of concern (oils, salts and metals).	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Highly probable (-3) **Significance: Medium-high (-11)**	• Implement post-combustion chamber monitoring in terms of water quality and pressure status. • Contaminated groundwater from combustion void pumped out and sent to the water treatment plant, quantified i.t.o. flow and water quality parameters. • Pump-out to cease once acceptable groundwater quality objectives have been met.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Highly probable (-3) **Significance: Medium-high (-10)**

7.11 Socio-economic

Table 66: Significance rating of socio-economic impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Arrival of construction workers.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Highly probable (-3) **Significance: Medium (-8)**	• Raise awareness amongst construction workers about local traditions and practices. • Inform local businesses that construction workers will move into the area to enable local businesses to plan for the extra demand. • Ensure that local communities communicate their expectations of construction workers' behaviour with them.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-6)**
	Possible inflow of unemployed job seekers.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Ensure that employment procedures / polices are communicated to local stakeholders (i.e. community representative organisations, ward councillors). • Have clear rules and regulations for access to the construction site to control loitering. Consult with the local SAPS to establish standard operating procedures for control and/or removal of loiterers at the construction site. • Construction workers should be clearly identifiable by wearing proper construction uniforms displaying the logo of the construction company. Construction workers may be issued with identification tags. • Contractor shall monitor areas where people gather on a regular basis as this is normally the first indication that (informal) settlement might be established in the area. These people should be removed in co-operation with the local SAPS to prevent the formation and/or expansion of informal settlements in the area.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Low (-5)**
	Change in community infrastructure (additional demand on services).	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Construction workers should be made aware of the limited capacity of the municipal services network. • Negotiations with the affected local municipalities must be conducted and a —demand-side management" should be implemented. • Sufficient portable chemical toilets should be provided on site and at the construction village (if applicable). • If applicable, contractors should ensure adequate sanitation services (e.g. showers) at the construction village with effective drainage facilities to ensure that used water is carried away from site.	**Extent:** Site (/1) **Duration:** Short-term (/1) **Intensity:** Low (/1) **Probability:** Improbable (/1) **Significance: Medium (/4)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Corporate Social Investment.	**Extent:** Local (/2) **Duration:** Short-term (/1) **Intensity:** Low (/1) **Probability:** Possible (/2) **Significance: Low (/6)**	EDF delivers on Eskom's CSI objectives by supporting economic and social projects initiated by registered Small, Medium and Micro Enterprises (SMMEs), with a special focus on communities within which Eskom operates its capital expansion projects.	**Extent:** Local (+2) **Duration:** Long-term (+3) **Intensity:** Moderate (+2) **Probability:** Highly probable (+3) **Significance: High (+10)**
	Dissimilarity in social practises.	**Extent:** Local (/2) **Duration:** Short-term (/1) **Intensity:** Low (/1) **Probability:** Possible (/2) **Significance: Low (/6)**	• Consult with the local municipality to establish a partnership as outlined in the municipality's IDP. • An aggressive STI and HIV/AIDS awareness campaign should be launched, which is not only directed at construction workers but also at the community as a whole. • Access at the construction site should be controlled to prevent sex workers from either visiting and/or loitering at the construction village or the construction sites. • Local women should be empowered. This could be achieved by employing them to work on the project, which in turn would decrease their (financial) vulnerability.	**Extent:** Site (/1) **Duration:** Short-term (/1) **Intensity:** Low (/1) **Probability:** Improbable (/1) **Significance: Low (/4)**
	Alteration in family structure.	**Extent:** National (-4) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: High (-12)**	• Consult with the local municipality to establish a partnership as outlined in the municipality's IDP. • An aggressive STI and HIV/AIDS awareness campaign should be launched, which is not only directed at construction workers but also at the community as a whole. • Access at the construction site should be controlled to prevent sex workers from either visiting and/or loitering at the construction village or the construction sites. • Local women should be empowered. This could be achieved by employing them to work on the project, which in turn would decrease their (financial) vulnerability.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Improbable (-1) **Significance: Medium (-8)**
Operations	Change in sense of place.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-9)**	• New infrastructure should be located in close proximity to existing infrastructure of a similar nature, as far as possible. • The future placement of pipelines should be done in consultation with affected landowners to minimise the impact on land use. • Rehabilitation of land to its previous condition should take place as soon as a pipeline is removed from a property. • Inform neighbouring property owners when construction will take place, including information on the nature and timeframe of the construction activities.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Medium (-7)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	Corporate Social Investment.	**Extent:** Local (/2) **Duration:** Short-term (/1) **Intensity:** Low (/1) **Probability:** Possible (/2) **Significance: Low (/6)**	• The EDF delivers on Eskom's CSI objectives by supporting economic and social projects initiated by registered Small, Medium and Micro Enterprises (SMMEs), with a special focus on communities within which Eskom operates its capital expansion projects.	**Extent:** Local (+2) **Duration:** Long-term (+3) **Intensity:** Moderate (+2) **Probability:** Highly probable (+3) **Significance: High (+10)**
Cumulative	Influx of job seekers – the influx of job seekers to the area can further tax the local services if not managed.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Ensure that employment procedures/polices are communicated to local stakeholders, especially community representative organisations and ward councillors. • Negotiations with the affected local municipalities must be conducted and a —demand-side management" should be implemented.	**Extent:** Site (/1) **Duration:** Short-term (/1) **Intensity:** Low (/1) **Probability:** Improbable (/1) **Significance: Medium (/4)**
	Corporate Social Investment.	**Extent:** Local (+2) **Duration:** Long-term (+3) **Intensity:** Moderate (+2) **Probability:** Highly probable (+3) **Significance: High (+10)**	The support of economic and social developments through Eskom's CSI can create sustainable projects that in turn create employment, reduce poverty levels and enhance the general quality of life of the local residents.	**No change**

7.12 Air Quality

Table 67: Significance rating of impacts on air quality

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Dust and emissions during construction generated by debris handling and debris piles, truck transport, bulldozing, general construction.	**Extent:** Local (-1) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Dust suppressed on the construction site and during the transportation of material during dry periods by regular application of water. Water used for this purpose must be used in quantities that will not result in the generation of run-off. • Loads could be covered to avoid loss of material in transport, especially if material is transported off site. • Dust and mud should be controlled at vehicle exit and entry points to prevent the dispersion of dust and mud beyond the site boundary. • Facilities for the washing of vehicles should be provided at the entry and exit points. • A speed limit of 40 km/hr should be set for all vehicles travelling over exposed areas. • During the transfer of materials, drop heights should be minimised to control the dispersion of mater being transferred. • Equipment used by the contractor must be maintained in good working order to prevent smoke emissions.	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-6)**
Operations	Emergency incidents when the transport of syngas to the Majuba Power Station is interrupted and the syngas needs to be flared.	**Extent:** Local (-2) **Duration:** Medium-term (-2) **Intensity:** Moderate (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**	High efficiency combustion of gases according to manufacturer's specifications should be achieved to limit the release of pollutants into the atmosphere.	**Unchanged**
Decommissioning	Dust and emissions during decommissioning generated by debris handling and debris piles, truck transport, bulldozing, general decommissioning activities.	**Extent:** Local (-1) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	***Refer to mitigation for construction phase dust and emission impacts.***	**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-6)**

7.13 Heritage

Table 68: Significance rating of impacts on heritage

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Impact on identified farmsteads and homesteads.	**Extent:** Site (-1) **Duration:** Permanent (-4) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-9)**	• Isolating known sites and declare them as no-go zones with sufficient large buffer zones around them for protection. In exceptional cases mitigation can be implemented after required procedures have been followed. • Contractors and workers should be notified that archaeological sites might be exposed during the construction activities. • Should any heritage artefacts be exposed during excavation, work on the area where the artefacts were discovered, shall cease immediately and the ECO shall be notified as soon as possible. • All discoveries reported immediately to a heritage practitioner so that an investigation and evaluation of the finds can be made. Acting upon advice from these specialists, the ECO will advise the necessary actions to be taken. • No artefacts shall be removed, destroyed or interfered with by anyone on site. • Contractors and workers shall be advised of the penalties associated with the unlawful removal of cultural, historical, archaeological or palaeontological artefacts, as set out in the National Heritage Resources Act (NHRA, Act No. 25 of 1999), Section 51. (1). • It is recommended that a responsible person (geologist, environmental officer, or other) regularly monitors excavations, removes and collects fossil material found. Fossils should be given to an institute that is recognized by SAHRA as a repository for fossils (e.g. Ditsong Museum or Council for Geosciences, Pretoria, or, Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg).	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
	Impact on informal cemeteries, burial grounds and other features identified in the study area (old bridge, hunting blinds).	**Extent:** Local (-2) **Duration:** Permanent (-4) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: High (-10)**		**Extent:** Local (-2) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-6)**

7.14 Noise

Table 69: Significance rating of noise impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	During the construction phase there is likely to be an increase in noise pollution from construction vehicles and construction staff.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• Provide all equipment with standard silencers. Maintain silencer units in vehicles and equipment in good working order. • Construction staff working in area where the 8-hour ambient noise levels exceed 85 dBA must have the appropriate Personal Protective Equipment (PPE).	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Low (-4)**
Decommissioning	During the decommissioning phase there is likely to be an increase in noise pollution from construction vehicles and construction staff.	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	***Refer to mitigation for construction phase noise impacts.***	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Low (-4)**

7.15 Traffic

Table 70: Significance rating of traffic impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction & Decommissioning	During the construction and decommissioning phases there is likely to be an increase in traffic from construction vehicles	**Extent:** Site (-1) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-7)**	• As per Eskom Policy, no person is allowed to drive more than 60 km/h on a gravel road (i.e. access roads on site). • All areas within the site itself, has a reduced speed limit of 30 km/h due to the danger of driving into the pipeline. This is communicated to all persons by means of National Speed Signs. • All vehicles entering UCG Site must be roadworthy. • Seatbelts are to be worn at all times. • When using heavy or large vehicles / equipment, "spotters" are to be present to assist the driver with his blind spots. • Any incident or damage to a vehicle must be reported immediately as per Eskom Policies and Procedures.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Low (-4)**

7.16 Visual

Table 71: Significance rating of visual impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Excavation for permanent structures associated with the proposed development (e.g. the Gas Treatment Plant) could create temporary un-vegetated areas in the landscape that could create a visual contrast with the natural vegetation.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity: Low** (-1) **Probability:** Possible (-2) **Significance: Low (-5)**	• Avoid unnecessary excavations / clearing of land and keep the construction footprint to a minimum. • Rehabilitate cleared areas as soon as possible.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Operation	**Gas Treatment Plant and emergency stack with flare** • Height of the stack (9 m) would make it visible from a wide around within, and surrounding the site. • Emergency flaring could cause the stack to become a visual focal point, especially at night when it could become a nuisance factor. • A quarter of static receptor locations are within the viewshed of the top of the stack.	**Extent:** Local (-2) **Duration:** Permanent (-4) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-9)**	• The topography on the site shields most of the receptor locations from a view of the GTP, stack and flare. • Avoid flaring as much as possible, especially at night time.	**Extent:** Local (-2) **Duration:** Permanent (-4) **Intensity: Low** (-1) **Probability:** Possible (-2) **Significance: Medium (-9)**
	Gasifier Units • Height of the gasifier units (maximum of 15m) would make the infrastructure visible from a wide area around the area in which the 9 units are planned. • A profusion of piping and related infrastructure over 9 gasifiers could enhance the industrial character of the immediate area (around Roodekopjes) as viewed from the surrounding area, thus increasing the industrial component in the landscape.	**Extent:** Local (-2) **Duration:** Medium Term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-8)**	• Reduce the design height of the gasifier units as much as possible, to reduce visual exposure over a wider area. • Gasifier units will only be operational for a short period (6-8 years), after which infrastructure will be dismantled. • All cleared / disturbed areas in the footprint of gasifier units to be rehabilitated with natural vegetation as soon as infrastructure has been dismantled. • Not all receptors will be within the viewshed of the gasifier units and most are located >2km distance, thus reducing the potential level of visual exposure.	**Extent:** Local (-2) **Duration:** Medium Term (-2) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Decommissioning	• Impact similar to construction – clearing of infrastructure could create bare, un-vegetated areas that would create a visual contrast with the natural vegetation. • Stockpiling of rubble / cleared infrastructure that is not removed could create a contrast with the aesthetics of the natural environment.	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-9)**	• Decommissioning to be monitored by an ECO according to the stipulations of the EMPr. • All rubble and cleared infrastructure to be properly removed and not left in situ. • All cleared areas / areas within the footprint of the UCG operation to be fully rehabilitated to their pre-construction state.	**Extent:** Site (-1) **Duration:** Short term (-1) **Intensity:** Low (-1) **Probability: Improbable** (-1) **Significance: Low (-4)**
Cumulative	Existing industrial infrastructure related to the Majuba Power Station creates a strong industrial visual component to an otherwise rural landscape. The development of the UCG operation, especially the GTP and the gasifiers would spatially extend the industrial component within the landscape, as viewed from surrounding areas. This could result in perceptions of the area increasingly being industrial, thus degrading the aesthetics of the rural environment.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Definite (-4) **Significance: Medium (-9)**	***Limit the UCG development to an area as close to the Majuba Power Station as possible.***	**Unchanged**

7.17 Water Treatment Alternatives

Alternatives have been identified in the parallel EIA process (and are being considered further), for the use of treated condensate, in terms of the S24G application at hand only one alternative is being considered as other alternatives would require additional new infrastructure and thus would fall outside of the specifications of the process at hand. That is, currently the condensate is being trucked away and disposed of at a licensed waste disposal site.

This option is interim and remains a critical issue under consideration in the on-going process. As however the alternatives are deemed to be inappropriate in this scenario, and as anything other than trucking away the condensate when it reaches a certain level would have dire consequences to the surrounding environment, it is taken that no further mitigation is required over that already in place (i.e. ensure that the existing dam does not leak, including monitoring to prove this, and only remove by a licensed service provider to a licensed waste disposal site).

Should the continuance of this practice not be allowed, a separate application will need to be lodged (either fully separate, or part of the parallel EIA process) for the decommissioning of the dam and development of an alternative solution (i.e. condensate dam in an appropriate position, linked to an increasing recycling / reuse option over time to minimise the waste disposal level).

8 ENVIRONMENTAL IMPACT STATEMENT

8.1 Summary of the Key Findings of the EIA

A summary of the key findings and recommendations are provided in **Table 72**.

Table 72: Summary of the key findings of the EIA study

Study	Findings	Recommendations
Geology	Geological and rock mechanic monitoring programmes are currently in progress / to be initiated. Subsidence beacons will be installed to verify baseline information with regards to any movement of the ground surface in and around the Gasifier 2 area prior to any events.	On-going geological and rock monitoring programmes are required to ensure a high level of certainty, reliability and assurance is achieved and maintained. The existing geological database must be continuously updated when new geological data is acquired.
Hydrogeology	Golder has constructed a numerical groundwater flow model in 2006 that was updated in 2010. During 2012, additional groundwater monitoring boreholes were installed focusing on gathering information on the identified gaps in the conceptual hydrogeological model. These holes are focussed around proposed Gasifier 2. These monitoring holes thus monitor specific hydrogeological units identified in the conceptual hydrogeological model. The updated hydrogeological conceptual model is based on the model constructed in 2010 and the numerical simulations were used for the groundwater impact assessment. Important findings	Groundwater level and quality monitoring is an essential management tool and is strictly required for the validity of a water use licence. Water quality monitoring provides early warning signs about the status of the resource and it allows the development of mitigation strategies to be implemented when necessary. The water resources (surface and groundwater) monitoring should continue at the Eskom UCG Majuba site. It is further recommended that the duration gap of groundwater and surface water quality data analysis and reporting should be reduced from 2 years to at

Study	Findings	Recommendations
	based on simulations, is that if no subsidence occurs, a 1 m drawdown impact is expected approximately 1.5 km within the coal seam water. Coal seam groundwater is not used and fit for consumption furthermore according to the current understanding of the hydrogeology, the B5 dolerite sill acts as a barrier and not impact on shallow groundwater levels is expected.	least 6 months. This will allow reporting on the status of the water system half yearly and will allow Eskom to respond to the recommendations, so as to implement the necessary controlling measures.
Hydrology	Main impact during construction and decommissioning is likely to be the run-off from the construction area into the Geelklipspruit. Potential impacts during operations include discharge of run-off from dirty areas such as workshop areas, roads and chemical storage areas, discharge of treated effluent from the wastewater treatment works, irrigation of treated condensate, overflow from contaminated storage dams and undermining the entire farm. In order to ensure that the medium to high impacts are mitigated, the Stormwater Management Plan proposes that channels carrying water from the dirty areas are not diverted into a pollution control dam but is monitored as the water is released into the watercourse. If the water quality from the monitoring points (as specified in the Stormwater Management Plan (**Appendix P (Sub-Appendix B)**) is not a good standard, the stormwater management plan will need to be readdressed, which could result in either a pollution dam being designed or a system in which the dirty water is stored and treated along with the process water before being released into the environment. Flood line delineation will help to ensure that the mine keeps all infrastructure out of the 1:50 flood lines. The dynamics of potential subsidence are unknown at this stage. Subsidence could result in a ridge or embankment whereby the upslope areas could be lower than the downslope areas. This would prevent the water which would normally move downslope from reaching the wetland. The subsidence may also affect groundwater inputs into the wetlands.	During construction and operation the surface water monitoring programme (four surface water monitoring points on site) must be kept in place and kept going until after decommissioning. Monitoring should be done on a monthly basis for all the parameters that are currently being undertaken and any further that would be written into a water use licence. A Stormwater Management Plan has been included in the EMPr (**Appendix P (Sub-Appendix B)**).

Study	Findings	Recommendations
Freshwater Ecology	The habitat integrity evaluation estimated the proposed river features (in the study area) to be in a C-class for its in-stream integrity (Moderately modified – a loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged) and in a D class for its riparian integrity (Largely modified - a large loss of natural habitat, biota and basic ecosystem functions has occurred). The ecological importance and sensitivity assessment analysis regards the study area's river features and highly important due to the Geelklipspruit catchment being classed as a Freshwater Ecological Priority Area (FEPA) as well as being very sensitive to erosion. The Present Ecological Status (PES) was used to establish the integrity of wetlands based on the modified habitat integrity approach. The habitat integrity assessment confirms modifications to the system and results in a C-classed (moderately modified) assessment for the proposed development area's wetland drainage features and a D-classed largely modified) assessment for the floodplain wetlands (valley-bottom wetlands).	All surface water resources that will be directly built on as part of this proposed development must be registered as part of a positive endorsed water use license. The surface water features in the study area are very sensitive in terms of channel and bank stability. Exposed banks can lead to site channels being further eroded and potentially vulnerable to invasive plant establishment. The study area and proposed development areas surface water resources have been qualified as highly important and sensitive, but in a moderate to largely modified ecological state. However, as with the wetlands found on site, these ecological ratings are not strongly correlated with the biodiversity importance of the area, but with the upstream location of these systems (upper Vaal River WMA tributaries forming part of river FEPA areas). The risk associated with the mismanagement of these surface water resources are significant and important to maintain in an ecologically sound condition.
Wetlands	A review of the functionality of the wetland reaches indicates a few aspects that are common to most of the wetlands in the study area. Erosion control is perhaps the most important. In most of the wetlands assessed, the vegetation cover was noted to be high. This is a critical factor in preventing the loss of erodible soils. Cattle trampling, however is an issue. Most of the wetland reaches were listed as being in a largely natural condition, with the categories of natural / unmodified' or largely natural' being assigned to most of the reaches. Furthermore large parts of the wetlands remain highly intact. Potentially medium to high negative impacts on wetlands in the study area include subsidence, irrigation with treated condensate, impact on shallow groundwater, construction of linear infrastructure (new service road and pipelines) and irresponsible construction practices. The removal of cattle during the operational life-time of the project is likely to be a positive impact as it will give the wetlands that have been subject to cattle-related impacts a chance to naturally recover and no further degradation would be likely to occur.	Very sensitive wetlands and their catchments must be avoided. No UCG mining should occur within the stipulated buffer areas i.e. no undermining should occur in the buffer. The following buffers are applicable: • Very High wetland sensitivity – the **entire** catchment of the reach should be included as part of the buffer. • High wetland sensitivity – a **100 m** buffer beyond the boundaries of the wetland. • Moderately High to Moderate wetland sensitivity – a **50 m** buffer beyond the boundaries of the wetland. The following exclusions must apply to the buffer areas: • No UCG mining activities should occur within the buffer area – i.e. no undermining should occur in the buffer. • The construction footprint should not affect the buffer zone in any way. • No storage areas for hazardous materials (such as fuel), parking areas for vehicles or any temporary toilets should be located within a 50 m zone beyond the buffer. It is recommended that gasification (sinking of wells)

Study	Findings	Recommendations
		should be designed in such a way that subsidence is greatly limited or does not occur. If the above is not possible, consideration of undermining of entire wetland unit catchments to ensure even subsidence across the catchment and not disrupt surface flows and sub-surface flows from the catchment into the wetlands is proposed. Under this scenario, it is uncertain the degree to which groundwater hydrological input into wetlands would be affected, therefore a technical solution that precludes undermining of wetlands as far as possible is advocated. In addition, in certain areas existing linear infrastructure run through the buffer zones. It is recommended that: • Existing access roads and tracks across wetlands must be used as far as possible, as these are typically associated with an existing impact on a wetland / stream. It is preferable for existing drifts / causeways to be upgraded rather than new road structures built into an un-impacted section of the wetland. • Where wetlands cannot be spanned by bridges, road design must incorporate a sufficient number and volume of culverts to allow flow within the wetland to pass under the road in as natural a manner as possible; i.e. flow within wetlands should be kept as diffuse as possible where diffuse flow occurs.
Soils and Agricultural Potential	The soils found on site are generally of medium to low agricultural potential (dryland and irrigated cropping) due to a number of reasons i.e. the soils are generally shallow with thin soil profiles overlying weathered rock or distinctly higher clay content sub-soils, due to the to the high clay content and shallow nature, the soils tend to hold limited quantities of water and due to the poor drainage as well as the presence of swelling clay, the soils are very susceptible to erosion. Surface run-off is a regular occurrence during rainfall events. When soils are exposed (through the removal of vegetation cover or other disturbances), the swelling nature of the clays contribute to the dispersive properties of the soil. The agricultural potential of the soils is considered to be low in terms of crop production but medium to high in terms of extensive grazing.	The existing mining process has impacted large areas but soil conditions have not be altered drastically due to the characteristics of the soils. In the case of swelling soils their self-mulching nature will lead to the disappearance of small disturbances over time. It is anticipated that the grazing potential of the impacted areas will be negatively impacted but it is possible that this potential will improve with time as the signs of impacts fade. The major risk to the soils is erosion due to the removal of the vegetation cover. All mining construction activities should take into account the erodibility of the soils and make provision for its prevention.
Biodiversity	From a biodiversity point of view no impacts were identified that could lead to a beneficial impact on	Considering the types of activities that will take place during potential construction and decommissioning

Study	Findings	Recommendations
	the ecological environment of the study area since the proposed development is largely destructive. Combined results from the floristic and faunal sensitivity analysis indicate the high sensitivity of the areas associated with wetland regimes. A medium-high ecological sensitivity is exhibited by the natural grassland areas of the study area, particularly as a result of the presence of several conservation important taxa and the high suitability of these areas for Red Data species.	phases, impacts on sensitive biodiversity attributes are nonetheless expected to occur, notwithstanding the implementation of mitigation measures, hence the relative high level of impact significance rating after the implementation of mitigation measures. Direct impacts on Red Data flora and fauna species as well as potential destruction of natural habitat are regarded unavoidable and it is strongly recommended that sensitive habitat types be excluded from the proposed development. One of the potential problems that will be encountered is the presence of Red Data fauna species within natural grassland habitat. An existing programme is in place where Sungazer lizards are located and removed to a suitable locality prior to the commencement of construction activities. This programme should be expanded to include other Red Data fauna and flora species and relevant identification and location programmes should be launched in the summer period when these species are most prevalent. Furthermore, construction and operational activities (as they occur) should be timed to coincide with the most likely absence of migratory species, i.e. the winter period. Areas that should be entirely excluded from the proposed development include outcrops and ridges as well as the wetland/ riparian habitat types. In addition, a suitable buffer zone around these areas should also be included as part of a —no-go zone. It was furthermore indicated that limited areas of moist grassland habitat will be affected by the proposed activity, but construction will be planned in such a manner that minimal infrastructure is placed within these areas. While any impact within this highly sensitive habitat is regarded severe, significant and undesirable, it was indicated that the exclusion of these areas will result in severe effects on the livelihood of the project. It is therefore strongly recommended that should this activity be allowed within this sensitive habitat type, site-specific mitigation measures be put into place in order to prevent, monitor and control activities within these areas. Areas of lower ecological sensitivities are not expected to be affected significantly by the proposed development and the implementation of generic mitigation measures are expected to prevent significant impacts. These areas should ideally be utilised for the placement of infrastructure and other activities that could potentially affect more sensitive

Study	Findings	Recommendations
		areas. Extreme caution needs to be taken during irrigation so that this water does not affect nearby riparian and wetland environments, particularly in view of the proximity of some agricultural areas to riparian environments.
Waste	During operations, the main impacts relate to the handling and treatment of UCG condensate. It is therefore imperative that there is continuous sampling and analysis of surface water quality in the targeted irrigation application area, including upstream and downstream. Sampling and analysis of the treated condensate stream for the target range of pollutants and water quality parameters must take place regularly. In terms of the water treatment plant, on-going monitoring of the inputs and outputs for the treatment plant must take place regularly. Monthly reports/records on removal efficiencies of the pollutants of concern such as phenol and PAHs must be compiled and filed on site. No untreated water is allowed to be released into any watercourse or used for irrigation. As a safety precaution, a process water dam with sufficient capacity will need to be constructed in order to cater for down-time of the water treatment plant. Admin-based wastewater, brine, solid sludge and particulates and spent activated carbon will transported off site and disposed of at an appropriately licensed facility.	An Integrated Water and Waste Management Plan has been drafted for the parallel Pilot Plant Phase 2 project that consolidates the various site specific programmes (e.g. water balance, water treatment and reuse, waste minimisation and handling). This document has not been completed and further needs to consider how to minimise potential impacts on the receiving environment.
Socio-economic	As could be expected, the construction phase is characterised by a number of negative social impacts (*viz*. arrival of construction workers; inflow of job seekers, additional demand on services) which is mainly due to the nature of the activities that take place during this phase. Although the expected social impacts associated with the construction phase are mostly negative across all the change processes (geographical; demographical; institutional and legal and socio-cultural), these impacts are for the most part only temporary in nature and as such are expected to only last over the construction period. Even though all of the identified social impacts can be mitigated or enhanced successfully, it can only be done if Eskom, or its appointed contractor(s), commit to the responsibility of ensuring that the level of disturbance brought about to the social environment by the more negative aspects of the	All mitigation measures in the Social Impact Assessment that are relevant to the construction phase must be incorporated into EMPr to ensure that these are adhered to by Eskom and the contractor/s. As part of the mining right application, Eskom has drafted a Social Labour Plan (SLP) that has been submitted to the Department of Minerals and Resources for approval. Due to the fact that UCG technology is still under research (and considering that the main development would only be localized to one farm with an existing workforce), no to very little money will be spent as part of the social and labour plan. Employment will be evaluated and as far as possible local members of the community will be considered for employment.

Study	Findings	Recommendations
	project, is minimised as far as possible. From an economic viewpoint, industrial developments often contribute indirectly to the regional and national economy by improving infrastructure, adding to the country's productive capacity, contributing to the country's capital goods and enabling economic growth. In the case of this project however, the long-term viability of the project still has to be proven and the project will not produce a saleable commodity.	
Air Quality	During construction and decommissioning, the pollutants likely to be emitted are particulate matter generated by vehicle movement and exposed soil to wind erosion. This is most likely to be a nuisance. In the case of operation of the UCG plant, there is only one pollution point source, the flare stack associated with the gas treatment plant. The emissions associated with flaring are predominantly hydrogen sulphide and other elements that are found in the syngas. The worst-case scenario of the flare being active for an hour under the worst meteorological conditions, the maximum concentration is well below the international standards and also below the odour thresholds. The dispersion plume does not extend far beyond the project boundary and can be reduced over a short time period.	Dust suppression activities (e.g. wet suppression with water) must be implemented during construction and decommissioning activities. High efficiency combustion of gas according to manufacturer's specifications should be achieved to limit the release of pollutants into the atmosphere.
Heritage	All objects of heritage significance found in the study area (e.g. farmsteads, homesteads, cemeteries and burial places as well as other features) have been categorised as Grade III resources according to Section 7 of the NHRA (No 25 of 1999). If mining activities have an impact on these resources then mitigation should isolating known sites and declaring them as no-go zones with sufficient large buffer zones around them for protection.	Known sites should be clearly marked in order that they can be avoided during construction activities. Should any heritage artefacts be exposed during excavation, work on the area where the artefacts were discovered, shall cease immediately and the Environmental Control Officer shall be notified as soon as possible. Under no circumstances shall any artefacts be removed, destroyed or interfered with by anyone on the site.
Noise and Traffic	The construction and decommissioning phases will see an increase in noise and traffic in the study area.	Impacts relating to noise and traffic can be effectively managed with the implementation of the EMPr.
Visual	A number of visual issues could be associated with the UCG development, mainly pertaining to its infrastructural components: • The Gas Treatment Plant's emergency stack could create a visual intrusion if flared, especially during night-time. • The gasifier units could be visible from a large area surrounding the site if they were constructed to their maximum height (15 m = 4-	A number of other mitigation measures, including the design of the gasifiers to as low a height as possible and the recommended re-alignment of the access road to the south away from the Skaapkraal farmstead would reduce the potential for the gasifiers and the service road respectively to result in significant visual impacts. Flaring should be prevented as much as possible, and be limited to daylight hours.

Study	Findings	Recommendations
	5 storeys), adding to the industrial component within the landscape. • The service road could create a high degree of visual intrusion for a nearby receptor location. A number of topographical-related factors would reduce the intensity of the visual intrusion created by the gas treatment plant and the gasifier unit, as the topography on the site would shield many of the receptor locations from a view of the proposed infrastructure. Moreover, most receptor locations would be located >2 km distance, greatly reducing the visual impact potential of the infrastructure at these locations.	

8.2 Implications of the Proposed Activity and Identified Alternatives on the Receiving Environment

Based on the Impact Assessment, a number of potentially negative and a few positive impacts have been identified and assessed across the life-cycle of the project.

8.2.1 Groundwater Levels and Quality

Groundwater levels and quality remains a pertinent issue associated with the project. Groundwater contamination is caused by the diffusion and penetration of contaminants generated by the underground gasification processes towards surrounding strata and the possible leaching of underground residue by natural groundwater flow after gasification. Typical organic pollutants include phenols, benzene, polycyclic aromatic hydrocarbons and hetrocyclics. Monitoring programmes have been conducted on site since 2006 and with the most recent monitoring study conducted during 2010 – 2012 together with the numerical modelling results, have shown that the if the lower B5 dolerite sill stays intact (i.e. no subsidence or goafing takes place) very limited impact on the shallow groundwater is expected. A 1 m drawdown impact is expected approximately 1.5 km within the coal seam groundwater, however, this groundwater is not used and is not fit for consumption.

8.2.2 Subsidence

For the partial undermining option, according to geological results, subsidence is not expected to occur, however, with the undermining of the entire farm, the proponent has indicated that up to 0.75 m of subsidence could occur. Indications are that gasification activities for the entire farm could lead to the subsidence of parts of the wetland catchment that are undermined, causing parts of the outer catchment to be lower than the inner catchment, significantly impacting surface and sub-surface (including groundwater) flows into the wetland. There would also be a number of likely knock-on impacts, in terms of impacts on the ecological state and functionality of the wetlands. It has been strongly recommended by the wetland specialist that sinking of the wells be done in such a manner that would avoid any surface / shallow underground subsidence which would subsequently diminish the impact on wetlands. In the event that the entire farm is undermined, as a worse case it is proposed that the undermining of wetlands and their catchments are preferred as this would result in even subsidence of the ground within the wetland and its catchment. However, it should be borne in mind that it is uncertain under this scenario, the degree to which groundwater hydrological input into the wetlands would be affected.

8.2.3 Soil Erosion

Owing to the nature of the soils in the study area (i.e. generally shallow with thin soil profiles overlying weathered rock or distinctly higher clay content sub-soils) the soils tend to hold limited quantities of water and due to the poor drainage, are very susceptible to erosion. Surface run-off is a regular occurrence during rainfall events. When soils are exposed (through the removal of vegetation cover or other disturbances), the swelling nature of the clays contribute to the dispersive properties of the soil. Appropriate erosion mitigation is included as part of the EMPr to prevent and reduce the risk of potential erosion.

8.2.4 Biodiversity

It should be reiterated that from a biodiversity point of view no impacts were identified that could lead to a beneficial impact on the ecological environment of the study area since the proposed development is largely destructive. However, compared with open cast coal mining that leaves large areas of land devoid of biodiversity, implementing UCG technology may not be as severe, as the gasfield comprises pipes and manifolds that are dissembled and the land rehabilitated as the gas field (gasifier) moves. Therefore, mitigation strategies and programmes highlighted in the EMPr should be complied with.

8.2.5 Socio-economic

Negative social impacts such as arrival of construction workers; inflow of unemployed work seekers; change in community infrastructure (additional demand on services); change in housing needs/demands; dissimilarity in social practises; alteration in family structure and change in sense of place have been assessed during this EIA study. Although these impacts are associated with the construction phase and are mostly negative across all change processes, these impacts are for the most part only temporary in nature and as such are expected to only last over the construction period.

Due to the fact that UCG technology is still under research, (and considering that the main development would only be localized to one farm with an existing workforce), no to very little money will be spent as part of the social and labour plan. Employment will be evaluated and as far as possible local members of the community will be considered for employment. Use of the farm for agriculture after mining has ceased and the land has been rehabilitated may be possible if the productive capacity of the land is intact as planned and Eskom rents the land to farmers. However, the practicality of this cannot be assessed as no precedence exists for this situation.

8.2.6 Condensate Handling and Treatment

At present, it is proposed that condensate will be treated using ultra-filtration. The treated water will then be used for irrigation.

However it should be noted that although the water treatment plant is in place the technology still requires refinement and as such to date the only solution has been the disposal of the condensate to a registered waste site by a registered specialist service provider. If the WTP is fine-tuned and becomes fully operational, it is recommended that until the condensate dam is formally decommissioned that the water so generated be used for irrigation. Note that if this is not approved in terms of the separate water use process being carried out with the Department of Water Affairs then the only alternative remaining is to dispose as per the current pattern for the foreseeable future.

8.2.7 Do-nothing Alternative

Compared against the do-nothing alternative, the above key impacts can be mitigated with the implementation of the EMPr and associated monitoring programmes (e.g. geology, rock mechanics, hydrogeology, surface water etc). Implementing UCG technology on the Majuba coal fields (which are judged uneconomic to mine) will further ensure provision of electricity by Eskom that is critical for industrial development and related employment and sustainable development in South Africa.

8.3 Opinion as to whether the Activity should or should not be Authorised

This document at hand provides an assessment of the benefits and potential negative impacts anticipated as a result of the project. It provides a description of the affected environment and alternatives proposed for the on-going operation, as linked to a formal rectification (post-fact authorisation) process, of the UCG Pilot Plant Phase 1 technology on the farm Roodekopjes 67HS. It further proposes different treatment and handling options of the condensate water i.e. irrigation, re-injection of water into the coal seam aquifer and purification to Majuba raw water quality specification.

Subsidence in a number of catchments across the study area could result in cumulative levels of wetland (hydrological) transformation across the catchment and could result in downstream hydrological impacts. It is therefore recommended, that very sensitive wetlands and their catchments be avoided. No UCG mining has occurred within the stipulated buffer areas to date.

The following buffers remain applicable: ~~V~~very High wetland sensitivity" – the entire catchment of the reach should be included as part of the buffer; ~~H~~igh wetland sensitivity" – 100 m buffer beyond the boundaries of the wetland and ~~M~~oderately High to Moderate" wetland sensitivity – 50 m buffer beyond the boundaries of the wetland.

It is understood that in certain areas existing infrastructure would run through the buffer zone. The mitigation measures proposed in the Wetland Report and EMPr should be enforced in the construction and operation of the roads through wetlands in the study area.

From a biodiversity point of view, undermining of the site would result in very high impacts associated with the destruction of conservation important taxa (*Boophone disticha*; *Crinum bulbispermum*; and *Gladiolus* species) observed during site investigations; have a direct impact on conservation important faunal species (e.g. Sungazer lizard) and would result in the destruction of sensitive/pristine habitat (wetlands). It is however noted that the existing footprint has had a minimal impact on the existing sensitive species and their habitats.

It is accepted that a high level of uncertainity exists with respect to the potential long-term impacts, however, it is understood that this is an implication of the research nature of the project and thus the reason for the relatively small footprint of the Pilot Plant Phase 1 (i.e. a balance between sufficient area to gain verifiable results, whilst minimising the overall risk).

It is further noted that the process has a long history of permits and approvals in place and that the dominant reason for the lack of compliance is related to time lines and changes in legislation impacting on said time lines.

The site has been in operation for a number of years, no significant environmental issues have occurred and the operation of the overall site remains commendable in terms of good practice.

It is recommended that given the information already generated through this project and the lack of environmental incidents to date on the greater site, that rectification be granted to allow the proposed future expansions to link into the existing development already in place.

8.4 Conditions

In order to achieve appropriate environmental management standards and ensure that the findings of the environmental studies are implemented through practical measures, the recommendations from this EIA study are included within an EMPr. The EMPr would be used to ensure compliance with environmental specifications and management measures. The implementation of this EMPr for the entire life cycle phases (i.e. construction, operation and decommissioning) of the project is considered to be vital in achieving the appropriate environmental management standards as detailed for this project.

In addition, the following key conditions should be included as part of the authorisation:

a) The proponent is not negated from complying with any other statutory requirements that is applicable to the undertaking of the activity. Relevant key legislation that must be complied with by the proponent includes *inter alia*:
   - Provisions of the National Water Act, 1998 (Act No 36 of 1998)
   - Provisions of the Minerals and Petroleum Resources Development Act, 2002 (Act 28 of 2002)
   - Provision of the National Heritage Resources Act, 1999 (Act No. 25 of 1999)

b) The proponent must appoint a suitably experienced (independent) Environmental Control Officer (ECO) for the construction phase of the development that will have the responsibility to ensure that the mitigation/rehabilitation measures and recommendations are implemented and to ensure compliance with the provisions of the EMPr.

c) The duration gap of groundwater and surface water quality data analysis and reporting should be reduced from 2 years to at least 6 months (to be confirmed). This will allow reporting on the status of the water system half yearly and will allow Eskom to respond to the recommendations, so as to implement the necessary controlling measures.

d) As a safety precaution, a dam with sufficient capacity will be constructed in order to cater for down-time of the water treatment plant. The location of this dam will still need to be determined. The environmental sensitivity map and flood line delineation will help to ensure that the mine keeps all infrastructure on the farm Roodekopjes 67HS out of the 1:50 flood lines.

e) Irrigation should be done according to the Management Plan proposed by Golder (Report No. 11613755/11857/2) which will need to be further revised to incorporate the recommendations by the wetland specialist (in terms of the parcels of land to be irrigated).

f) The Integrated Water and Waste Management Plan must be compiled with.

g) At the Skulpspruit 3 crossing, where the new road runs longitudinally as opposed to across the wetland perpendicular to the direction of flow / the slope, the road should be aligned slightly to the north in this section (approximately 50 m) to avoid the wetland completely.

h) Very sensitive wetlands and their catchments must be avoided. No UCG mining should occur within the stipulated buffer areas i.e. no undermining should occur in the buffer. The following buffers are applicable: Very High wetland sensitivity – the entire catchment of the reach should be included as part of the buffer; High wetland sensitivity – a 100 m buffer beyond the boundaries of the wetland and Moderately High to Moderate wetland sensitivity – a 50 m buffer beyond the boundaries of the wetland.

8.5 Assumptions, Uncertainties or Gaps in Knowledge

- All information provided by Eskom Holdings SoC Ltd to the EAP was correct and valid at the time it was provided.
- All data from unpublished research is valid and accurate.
- Due to the research nature of the project, there are some information gaps (e.g. impact of subsidence on groundwater flows into wetlands, design of the new service road, new safety dam location), and these have been further highlighted in the **Section 6** (Specialist Findings and Recommendations) and **Section 7** (Impact Assessment). As soon as information that is more detailed comes to light, the EIA study will need to be revisited and updated.
- Only irrigation has been assessed as an end-use for the treated condensate.

In addition to the assumptions above, the following assumptions and limitations were noted by the specialist team.

Table 73: Assumptions, limitations and uncertainties

Specialist Field	Assumptions, Limitations and Uncertainties
Hydrogeology	• Where data supplied by the proponent or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others. • Conditions may exist which were undetectable given the limited nature of the enquiry, Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the hydrogeological study. Accordingly, additional studies and actions may be required.
Wetlands	• Only wetlands within the boundaries of the revised study area were assessed as part of this study, and no downstream or upstream wetlands were assessed / delineated. • The study has aimed to assess the wetlands in the study area as far as possible; however bearing in mind budgetary limitations, a full in-field delineation of all wetlands in the extensive study area has not been undertaken. Most wetland units were able to be visited in the field, however, and where possible soil and vegetative indicators were examined to determine the actual extent of wetlands on the ground. • Certain of the wetland surveys were undertaken in winter. Although this has allowed a very useful seasonal assessment of wetland conditions to be undertaken, not all wetlands in the study area were visited during the growing season. • No detailed modelling of the potential impact of the proposed UCG mining operations on ground subsidence has been provided for assessment. Combined with the lack of detailed groundwater flow modelling, it is thus not possible to accurately assess the wetland-specific impacts of subsidence on groundwater inputs into wetlands on the site. Should this information be made available, a wetland-level assessment of the potential impacts of subsidence would be able to be undertaken.

Freshwater Ecology	• Limitations and uncertainties often exist within the various techniques adopted to assess the condition of ecosystems. The following limitations apply to the techniques and methodology utilized to undertake this study:
	  ○ Analysis of the freshwater ecosystems was undertaken according to nationally developed methodologies as defined by DWA (Department of Water Affairs) and/or DEA (Department of Environmental Affairs).
	  ○ Most of the information used to characterise potentially affected water resources for this report is sourced from DWA and DEA online GIS tools. This is supplemented by the use of Google Earth.

Specialist Field	Assumptions, Limitations and Uncertainties
	○ Recommendations are based on professional opinion and best practise guidelines within South Africa.
Biodiversity	• Findings, results, observations, conclusions and recommendations presented in this biodiversity report are based on the authors' best scientific and professional knowledge as well as the interpretation of information available to them at the time of compiling this report. • It is emphasised that information, as presented in this document, only have bearing on the site as indicated in the accompanying maps part of the reports. This information cannot be applied to any other area, however similar in appearance or any other aspect, without proper investigation. • Results presented in this report are based on a snapshot investigation of the study area and not on detailed and long-term investigations of all environmental attributes and the varying degrees of biological diversity that may be present in the study area. • Rare and endemic species normally do not occur in great densities and, because of customary limitations in the search and identification of Red Listed species, the detailed investigation of these species was not possible. Results are ultimately based on estimations and specialist interpretation of imperfect data • The biodiversity report should always be considered as a whole. Reading and representing portions of the report in isolation could lead to incorrect conclusions and assumptions. In case of any uncertainty, the authors should be contacted to clarify any viewpoints, recommendations and/ or results.
Waste	• The work undertaken for the waste impact assessment was based on information supplied by the proponent. In some areas, assumptions were used based on best available information. Noting that this is an initial phase of the UCG process, it is considered that there is sufficient provision in the mitigation and EMPr measures to be protective of the environment and to conform with legislative and regulatory provisions.
Social	• This report is a revision of the original SIA report that was initially compiled for the OCGT that formed part of the UCG (January 2011) and is based on several scope changes as outlined in the overall Scoping Report compiled by Royal HaskoningDHV (January 2013). Due to budgetary and time constraints, it was not possible for the specialist to engage stakeholders in the compilation of this report. • This study was carried out with the information available to the specialist at the time of executing the study, within the available timeframe and budget. The sources consulted are not exhaustive, additional information which might strengthen arguments or contradict information in this report might exist. • The specialists did endeavour to take an evidence-based approach in the compilation of this report and did not intentionally exclude scientific information relevant to the assessment. • It was assumed that the motivation for, and the ensuing planning and feasibility studies of the project were done with integrity, and that the information provided to date by the project proponent, the independent environmental assessment practitioner and the public participation consultant was accurate.
Air quality	• The emissions inventory has been developed in conjunction with the staff from Eskom, who provided mass balance calculations, input parameters and monitored data from various sources. • Volatile Organic Compounds were reported as benzene in order to assess impacts against an available South African Ambient Standard. • It was assumed that the flaring occurred 24 hours a day, 365 days a year.
Visual	• No detailed contour information for the wider study area was available, hence the country-wide 20 m-interval contour data was used for the generation of the viewshed of the gas treatment plant. • No detailed design (especially height) information relating to the gasifier units has been provided for assessment. Accordingly the assessment of the likely visual impact and visual intrusion factor associated with the gasifier units has been limited. • No detailed information relating to the exact results of subsidence has been provided. Accordingly only a general assessment of the visual impacts associated with potential subsidence has been provided.