May 2017

AFRICAN CARBON ENERGY (PTY) LTD

Draft EIA Report: Underground Coal Gasification and Power Generation Project near Theunissen

Due date for public comment: Wednesday 21 June 2017

DMR Reference numbers: FS30/5/1/2/2/10034MR and

FS 30/5/1/2/3/2/1(10034) EM

NEAS Reference number: DEA/EIA/0002354/2014

DEA Reference number: 14/12/16/3/3/3/116

DETEA Reference number: EMS/9,22,23,3,4,5,26/13/11

Submitted to:
Department of Mineral Resources
Department of Environmental Affairs
Department of Economic Development, Tourism and Environmental Affairs

REPORT

Report Number: 1665716-314466-1

Distribution:

African Carbon Energy
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PURPOSE OF THIS DOCUMENT

African Carbon Energy (Pty) Ltd (Africary) has acquired prospecting rights for coal in the Free State Province and proposes to establish an underground coal gasification (UCG) project with a typical 50 to 60 megawatt (MW) electrical power plant on the farm Palmietkuil 548 about 26 km north-north-west of Theunissen. The UCG facilities at surface and the power plant will occupy a site of about 3 hectares on the surface.

In terms of the Mineral and Petroleum Resources Development Act (No 28 of 2002, hereafter MPRDA) and the MPRDA Regulations R.527, Africary must submit an application for a mining right to the Department of Mineral Resources (DMR). Africary must also submit an Environmental Management Programme (EMP), which describes how the environmental impacts of the proposed development will be managed and mitigated. The EMP must be based on an Environmental Impact Assessment (EIA).

Africary undertook an EIA during 2013 and 2014 in terms of the EIA Regulations GN R.543, GN R.544 and GN R.545, which commenced in June 2010. On 2 September 2015 the Department of Environmental Affairs (DEA) granted an integrated environmental authorisation (number 14/12/16/3/3/3/116) for all the listed activities applied for. The authorisation included a waste management licence (WML). On 16 November 2015 the Lejweleputswa District Municipality granted a provisional Atmospheric Emissions Licence (number LDM/AEL/LCR/005).

Africary will also require a water use licence (WUL) and an integrated water and waste management plan (IWWMP).

Golder Associates Africa (Pty) Ltd (Golder), an independent environmental and engineering company, was appointed by Africary to conduct the required environmental authorisation and licensing processes for the proposed project.

Africary submitted a mining right application (MRA) on 30 November 2015 (Reference number FS30/5/1/2/2/10030MR), but in terms of the EIA Regulations GN R.984 of 8 December 2014, an application for a mining right must be followed by an application for environmental authorisation of the mining activities, which, prior to 8 December 2014, were authorized when the DMR approved the EMPr and issued a mining right. Said application for authorisation triggers an EIA process.

The EIA documentation that had been approved by the DEA was submitted in support of the new application. However, the DMR had developed a new format for the EIA documentation (application form, scoping report, EIA report and EMPr) and rejected the application. After consultation with the DMR, the pending MRA was withdrawn and a new MRA and environmental authorisation application (EAA) were submitted on 6 December 2016. The new MRA was accepted on 21 December 2016, and a new reference number (FS30/5/1/2/2/10034MR) was issued.

The first phase of an EIA is the Scoping Phase, during which interested and affected parties are given the opportunity to comment on the proposed activities and the proposed scope of the EIA specialist studies. The Final Scoping Report (FSR) in the new DMR format was made available for public comment from 4 October to 3 November 2016.

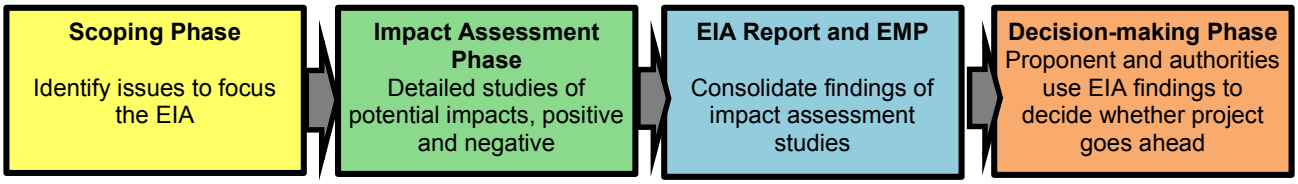
This Draft EIA/EMPr Report, which has also been compiled in the new DMR format, contains essentially the same information as the EIA/EMPr Report that was approved by the DEA in September 2015. It is being presented to stakeholders for their review and an opportunity to provide comments and/or raise issues of concern.

The due date for comment on the Draft EIA Report and Draft EMPr is **Wednesday 21 June 2017**. Comments received during the public review period will be acknowledged and recorded in the Final Comment and Response Report, which will be provided to the DMR.

Summary of what the EIA/EMPr report contains

This report contains:

- A description of the proposed project and the activities to be authorised;
- An overview of the EIA process, including public participation;
- A description of the existing environment in the proposed project area;
- The environmental issues and impacts which were identified during the scoping phase;
- The Plan of Study for impact assessment and terms of reference of the specialist studies undertaken during the Impact Assessment phase;
- A list of interested and affected parties involved during the EIA process and their comments (Comments and Response Report); and
- The assessed environmental impacts and recommended mitigation measures.



The figure above shows the various phases of an EIA. This EIA is at the end of the Impact Assessment Phase, during which interested and affected parties were informed of and invited to comment on the proposed project and the findings of the specialist studies

PUBLIC REVIEW OF THE EIA REPORT AND EMP

The Draft EIA/EMPr Report is available for comment for a period of 30 days from **Friday, 19 May 2017 to Wednesday, 21 June 2017**. Copies of the Draft EIA Report and Draft EMPr are available at strategic public places in the project area (see below), at www.Golder.com/public and upon request at the Public Participation Office of Golder Associates.

Name of Public Place	Contact Person	Contact Number
Welkom Public Library	The Librarian	(057) 391 3131
Theunissen Public Library	The Librarian	(057) 733 0106
Golder Associates Africa, Midrand	Ms Antoinette Pietersen	(011) 254 4800

OPPORTUNITIES FOR PUBLIC REVIEW

Stakeholders wishing to comment on the Draft EIA Report and Draft EMPr may do so in any of the following ways:

- Completing the comment sheet enclosed with this report;
- Additional written submissions;
- Comment by e-mail or telephone;

DUE DATE FOR COMMENT ON THIS EIA REPORT IS WEDNESDAY, 21 JUNE 2017

Please send your comments to the Public Participation Office:

Antoinette Pietersen
Golder Associates
P O Box 6001
HALFWAY HOUSE, 1685
Tel: (011) 254 4800
Fax: 086 582 1561
Email: APietersen@golder.co.za

Executive Summary

Africary Holdings (Pty) Ltd (Africary) has acquired the coal rights over an area of more than 300 square kilometres near Theunissen and is proposing to develop underground coal gasification (UCG) as a means of exploiting the coal reserves to produce electricity.

The aim of the project is to generate and sell 50 to 60 MW of electricity into the grid based on a de-rated installed capacity of 77 MW *via* the gasification of about 5 million tons of coal over 20 years under an area of about 150 out of the 600 hectares available on the farm Palmietkuil. The power plant and ancillaries will have a footprint of about 3 hectares and will be connected to the national grid *via* a ±13 km power line An existing canal will bring water to the site from the Sand-Vet Water Users Association (WUA) system. If technically and commercially successful, the project may be expanded in generation capacity and extended to the rest of the coal field.

An environmental impact assessment (EIA) has been undertaken and an environmental management programme (EMPr) has been developed. The main identified impacts are summarised below.

Air quality

The construction and closure/rehabilitation phases will cause dust emissions to atmosphere. These can be readily controlled by wet suppression to an impact of ***low*** significance.

Normal operating conditions will not affect air quality in the region significantly. Venting could raise ambient CO levels to 50% of the one-hour South African standard over a substantial area and up to 80% of the standard in a few small spots some 5 km to the south and south-south-east of the power plant site. Flaring could raise ambient SO_2 levels to 50% of the one-hour South African standard over a fairly large area and up to 70% of the standard in a few small areas some 5 km to the south and south-south-east of the power plant site. Venting and flaring are expected to be rare events of short duration and the air quality impact can be mitigated to one of ***low*** significance by implementation of the recommended mitigation measures.

Noise

The construction and closure/rehabilitation phases will be audible at the nearest farmhouses, but will not exceed national standards or reach intrusive levels.

Africary considered both gas turbines and reciprocating engines as drivers for the power generator. The use of gas turbines would generate unacceptable noise at the nearest farmhouse and intrusive noise levels at most farmhouses within about 4 km of the site. A power plant based on reciprocating engines will cause night-time intrusive noise levels at the nearest farmstead only and Africary has accepted reciprocating engines as the preferred choice.

Soils, land capability and land use

The soils on the plant site and along the preferred power line and pipeline route are erosion sensitive and the potential for loss of topsoil will be high during construction and closure/rehabilitation. Other potential impacts include contamination with hydrocarbons, hydraulic fluids, cement, paint and solvents, and degradation of quality due to mixing with subsoil when excavating foundation trenches and the basins for the brine ponds.

Potential contamination with brine, hydrocarbons and process chemicals is also possible during the operational phase.

Soil impacts can be mitigated to ***low*** significance by application of the recommended mitigation measures and the agricultural potential of the affected area can be largely restored after closure.

Surface water

Surface water contamination during construction and closure/rehabilitation is directly linked to the potential for soil contamination and the impact can be mitigated to ***low*** significance by application of the recommended mitigation measures.

Contamination of surface water resources could occur during the operational phase if the bunds and/or brine ponds leak or overflow or if process chemicals and/or wastes are stored outside of the bunded areas. If gas

from the underground gasifier were to leak past the borehole casings and grouting seals and cause contamination of the shallow aquifer, such contamination could migrate into the surface water resources.

Any such contamination should be temporary as it can be readily detected and stopped. Implementation of the recommended mitigation measures is expected to reduce the probability of surface water contamination to a ***low*** level.

Groundwater

The potential for contamination of the shallow aquifer water during construction and closure/rehabilitation is also linked to the potential for soil contamination. It can be mitigated to an impact of ***low*** significance by application of the recommended mitigation measures.

Due to the thickness and low hydraulic conductivity of the geological formations overlying the coal seam, there is no connectivity between the shallow and deep aquifers. The same low hydraulic conductivity will prevent pollution of the deep aquifer by migration of contaminants from the underground coal gasifier during and after the gasification process.

Inappropriate construction of the injection and production boreholes and/or inadequate sealing of exploration boreholes could result in the syngas escaping into the shallow aquifer region and the atmosphere and potentially cause an impact of ***high*** significance. Making use of a specialised drilling contractor with adequate knowledge of gas field drilling is recommended to reduce the probability of pollution by fugitive syngas to a ***very low*** level

Terrestrial Ecology

The project is located in the savannah grasslands of the Free State in the central region of South Africa. The grasslands have largely been converted to agricultural fields, resulting in low biodiversity.

Construction will result in the total removal of vegetation and topsoil from an area of about 3 ha on the power plant site and from a 2 metre wide strip along the pipeline route. Human presence and noise are likely to drive most species of fauna away during all three phases of the project. Application of the recommended mitigation measure can reduce the impact to one of ***low*** significance.

The mitigation measures recommended for the rehabilitation phase could improve the ecology on the site from its pre-project condition and result in a positive impact of ***moderate*** significance.

Socio-economics

The construction phase will require up to 200 contract workers for a period of about 12 to 15 months and involve capital expenditure of approximately R1.5 billion with a local content of about 20% for labour and 27% for fabrication.

The operational phase will employ 33 people or about ten people per shift and the power production will increase the national power generation capacity by about 0.125%.

While these figures translate into a ***low*** socio-economic impact, the long term potential of this and other UCG projects to unlock currently non-viable coal reserves and generate power from coal in a more environmentally friendly manner is considerable.

Cultural and Heritage Resources

The two graveyards identified in the vicinity of the power plant site will not be affected by the project and the old farmstead structures will be used for offices, which will preserve and maintain them. Unearthing of buried remains and artefacts during construction cannot be ruled out and could potentially have ***high*** impact, which can be mitigated to ***low*** impact by applying the recommended chance find procedures.

Visual aspects

The construction and operational phases will potentially have ***moderate*** visual impact due to the establishment of tall structures in this largely rural area. Flaring at night would have a ***high*** visual impact.

The visual impacts can be reduced to ***low/moderate*** significance by implementation of the recommended mitigation measures.

Table of Contents

1.0 INTRODUCTION 1
1.1 Project Background 1
1.2 Permitting History 1
2.0 PROPONENT AND PRACTITIONER DETAILS 2
2.1 Details of the proponent 2
2.2 Details of Environmental Assessment Practitioner 2
2.2.1 Expertise of environmental assessment practitioners 3
2.2.1.1 Qualifications 3
2.2.1.2 Summary of past experience 3
2.3 Description of the property 4
2.4 Locality map 4
2.4.1 Magisterial District and relevant Local Authority 4
2.4.2 Landowners and use of immediately adjacent land 4
2.5 Description and Scope of the Proposed Overall Activity 4
2.5.1 Listed and specific activities 5
2.5.2 Description of the activities to be undertaken 6
2.5.2.1 Underground coal gasification 6
2.5.2.2 Syngas processing and power generation 12
2.5.2.3 Electricity distribution 14
2.5.2.4 Establishment of utilities and ancillaries 14
2.5.2.4.1 Gaseous utilities 15
2.5.2.4.2 Process water 15
2.5.2.4.3 Fuels 15
2.5.2.4.4 Catalysts and Chemicals 15
2.5.2.5 Plant effluent 15
2.5.2.6 Infrastructure requirements 16
2.5.2.7 Safety, Security, Health and Environmental Issues 18
2.5.2.7.1 Safety 18
2.5.2.7.2 Security 18
2.5.2.7.3 Health 18
2.5.2.7.4 Environment 18

2.5.2.7.5 Mobility and Modularity 19
2.5.2.8 Design Life 19
3.0 POLICY AND LEGISLATIVE CONTEXT 19
3.1 South African Legislation 19
3.1.1 National Environmental Management Act, 1998 (Act 107 of 1998) 19
3.1.2 Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA) 20
3.1.3 National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEMWA) 20
3.1.4 National Water Act, 1998 (Act 36 of 1998) 20
3.1.5 National Environmental Management: Air Quality Act 2004, (Act 39 of 2004) (NEMAQA) 21
3.1.6 Occupational Health and Safety Act, 1993(Act 85 of 1993) 21
3.1.7 National Heritage Resources, 1999 (Act 25 of 1999) (NHRA) 22
3.2 International 22
3.2.1 International Conventions and Agreements 23
3.2.2 International Finance Corporation Performance Standards 26
3.2.3 Equator Principles 27
3.2.4 The World Bank Group Environmental Health and Safety (EHS) Guidelines 28
3.2.5 Environmental and Social Management System and Action Plans to be developed 28
3.2.6 Health, Safety and Security 29
3.2.7 Safety, Health, Environment and Community Policy 29
3.2.8 Emergency Response Plans 29
3.3 Administrative Framework 30
3.3.1 Department of Mineral Resources (DMR) 30
3.3.2 Department of Economic Development, Tourism and Environmental Affairs Free State Province (DETEA) 30
3.3.3 Department of Environmental Affairs (DEA) 30
3.3.4 Department of Water Affairs 30
4.0 PROJECT MOTIVATION: NEED AND DESIRABILITY OF PROPOSED ACTIVITIES 31
5.0 PROJECT ALTERNATIVES AND PROCESS FOLLOWED TO REACH PREFERRED ALTERNATIVE 31
5.1 Alternative Power Plant Sites 32
5.2 Alternative UCG Target Areas 32
5.3 Alternative Means of Power Generation 34
5.4 Air Enrichment 35
5.5 Syngas Desulphurisation 35

5.6 Water Supply 35
5.7 Wastewater Treatment 36
5.8 Alternative routes for power line and water pipeline 37
5.9 Post-closure land use 37
5.10 No-Project Option 39
6.0 PUBLIC PARTICIPATION 39
6.1 Objectives of public participation 39
6.2 Identification and Registration of Interested and Affected Parties 40
6.3 Public participation during the Scoping phase 40
6.3.1 Announcement of the proposed project 40
6.4 Public Participation during the Impact Assessment Phase 41
6.5 Public Participation during the Decision-making Phase 41
6.6 Summary of Issues Raised by I&APs 41
7.0 ENVIRONMENTAL ATTRIBUTES AND DESCRIPTION OF THE BASELINE RECEIVING ENVIRONMENT 41
7.1 Climate 41
7.1.1 Temperature 44
7.1.2 Evaporation 45
7.1.3 Rainfall 45
7.1.4 Wind 46
7.2 Air Quality 48
7.3 Noise 49
7.3.1 Methodology 49
7.3.2 Baseline noise levels 49
7.4 Topography 53
7.5 Geology 54
7.5.1 Regional Geology 54
7.5.2 Local Geology 54
7.5.3 Coal Specifications 55
7.6 Soils and land types 55
7.6.1 Land types 55
7.6.2 Classification of Soils 55
7.6.3 Soil chemistry and fertility status 59
7.6.4 Land capability and land use 60

7.7 Surface Water 64
7.7.1 Water Management Area 64
7.7.2 Surface Water Resources 66
7.7.3 Rainfall and evaporation 68
7.7.4 Evaporation 69
7.7.5 Baseline Flow and Water Quality 70
7.7.6 Flood line determination 73
7.8 Groundwater 76
7.8.1 Regional groundwater conditions 76
7.8.2 Baseline groundwater conditions at UCG target area 76
7.9 Terrestrial Ecology 81
7.9.1 Regional setting and characteristics 81
7.9.2 Vegetation 83
7.9.3 Fauna 86
7.9.3.1 Avifauna 86
7.9.3.2 Mammalia 87
7.9.3.3 Reptiles 87
7.9.4 Amphibia 88
7.9.5 Fish 88
7.9.6 Alternatives and ecological considerations 88
7.10 Socio-economic Environment 90
7.10.1 Administrative Setting 90
7.10.2 Economic Activities 90
7.10.3 Population Demographics 91
7.10.4 Employment Levels 91
7.11 Cultural and Heritage Resources 92
7.11.1 Methodology 92
7.11.2 Historical background 92
7.11.3 Types and ranges of heritage resources 93
7.12 Visual aspects 97
7.12.1 Visual characteristics of the project area 97
7.12.2 Visual resource value of the project area 99
7.12.3 Visual absorption capacity of the project area 100

7.12.1 Receptor sensitivity 102
8.0 IMPACTS AND RISKS IDENTIFIED 102
9.0 IMPACT ASSESSMENT PROCESS AND METHODOLOGY 102
9.1 Scoping Methodology 103
9.2 Impact Assessment Methodology 104
9.3 Positive and negative impacts of initial site layout and alternatives 105
9.4 Possible mitigation measures and levels of risk 105
9.5 Motivation where no alternative sites were considered 106
9.6 Statement motivating the preferred site and layout 106
9.7 Process undertaken to identify, assess and rank impacts and risks imposed on preferred site. 106
10.0 ENVIRONMENTAL IMPACT ASSESSMENT 106
10.1 Project Phases and Activities 106
10.1.1 Construction 107
10.1.2 Operation 107
10.1.3 Closure and rehabilitation 108
11.0 FINDINGS OF THE ENVIRONMENTAL IMPACT ASSESSMENT STUDIES 108
11.1 Air quality 108
11.1.1 Ambient air quality standards and guidelines 108
11.1.2 Emission standards 109
11.1.2.1 Current South African emission standards 109
11.1.3 International guidelines 112
11.1.3.1 Emission guidelines 112
11.1.3.2 Ambient air quality guidelines 112
11.1.4 Key pollutants and associated health effects 113
11.1.5 Emissions inventory 114
11.1.6 Impact Assessment 115
11.1.6.1 Construction 117
11.1.6.2 Operation 117
11.1.6.2.1 Dispersion modelling results 118
11.1.6.2.2 Impacts and mitigation measures 126
11.1.6.3 Closure and rehabilitation 127
11.2 Noise 127
11.2.1 Standards and guidelines 127

11.2.2 Assessment of noise impact 129
11.2.2.1 Construction 129
11.2.2.2 Operation 130
11.2.2.3 Closure and rehabilitation 133
11.3 Topography 134
11.3.1 Construction 134
11.3.2 Operation 134
11.3.3 Closure and rehabilitation 134
11.4 Geology 134
11.4.1 Construction 134
11.4.2 Operation 135
11.4.3 Closure and rehabilitation 135
11.5 Soils, land capability and land use 135
11.5.1 Construction 135
11.5.2 Operation 135
11.5.3 Closure and rehabilitation 136
11.6 Surface water 136
11.6.1 Proposed stormwater management plan 136
11.6.1 Modelling the Stormwater Management System 139
11.6.2 Channel characteristics 139
11.6.3 Water schematic 139
11.6.4 Water quality monitoring 142
11.6.5 Impact Assessment 142
11.6.5.1 Construction 142
11.6.5.2 Operation 143
11.6.5.3 Closure and rehabilitation 143
11.7 Groundwater 143
11.7.1 Construction 147
11.7.2 Operation 147
11.7.3 Closure and rehabilitation 150
11.8 Terrestrial Ecology 150
11.8.1 Construction 150
11.8.2 Operation 151

11.8.3 Closure and rehabilitation 151
11.9 Socio-economics 152
11.9.1 Construction 152
11.9.2 Operation 153
11.9.3 Closure and rehabilitation 153
11.10 Cultural and Heritage Resources 154
11.10.1 Construction 154
11.10.2 Operation 154
11.10.3 Closure and rehabilitation 154
11.11 Visual 155
11.11.1 Construction 155
11.11.2 Operation 155
11.11.3 Closure and rehabilitation 155
12.0 SUMMARY OF ENVIRONMENTAL IMPACTS 156
12.1 Construction Phase 156
12.2 Operational Phase 157
12.3 Closure and rehabilitation Phase 159
13.0 ENVIRONMENTAL IMPACT STATEMENT 160
13.1 Summary of key findings of the EIA 160
13.1.1 Air quality 160
13.1.2 Noise 160
13.1.3 Surface water 160
13.1.4 Groundwater 161
13.1.5 Visual 161
13.1.6 Waste management 161
13.2 Final site maps 161
13.3 Summary of positive and negative implications and risks of proposed activity and alternatives 161
14.0 IMPACT MANAGEMENT OBJECTIVES AND OUTCOMES FOR INCLUSION IN THE EMPR. 162
14.1 Final proposed alternative 163
14.2 Aspects for inclusion as conditions of authorisation 163
14.3 Assumptions, uncertainties and gaps in knowledge 163
14.4 Opinion on whether the activity should be authorised 163
14.5 Reasons why the project should be authorised 163

14.6 Conditions that must be included in the authorisation 164
14.6.1 General conditions 164
14.6.2 Specific conditions 164
14.6.3 Rehabilitation requirements 164
14.7 Period for which environmental authorisation is required 165
14.8 Undertaking 165
14.9 Financial Provision 165
14.10 Deviations from approved scoping report and plan of study 165
14.11 Other information required by the DMR 166
14.11.1 Impact on socio-economic conditions of any directly affected person 166
14.11.2 Impact on any national estate 166
14.11.3 Other matters required in terms of section 24(4) of the NEMA 166
15.0 DRAFT ENVIRONMENTAL MANAGEMENT PROGRAMME 166
15.1 Details of Environmental Assessment Practitioner 166
15.2 Description of the Aspects of the Activity 166
15.3 Composite Map 166
15.4 Impact Management Objectives and Statements 168
15.4.1 Determination of closure objectives 168
15.4.2 Environmental Quality and managing environmental impacts 168
15.4.3 Potential risk of acid mine drainage 168
15.4.4 Water use 169
15.5 Impacts to be mitigated and monitored in their respective phases 169
16.0 FINANCIAL PROVISION 182
16.1 Overall Closure Goal 182
16.2 Closure Objectives 182
16.2.1 Physical Stability 182
16.2.2 Environmental Quality 182
16.2.3 Health and Safety 182
16.2.4 Land Capability/Land-use 183
16.2.5 Aesthetic Quality 183
16.2.6 Biodiversity 183
16.2.7 Socio-economic Aspects 183
16.3 Closure costing 184

16.3.1 Assumptions 184
16.3.2 Closure cost scenarios and estimates 184
16.3.2.1 Annual rehabilitation and scheduled closure cost 184
16.3.2.2 Latent risk closure costs 184
16.3.3 Recommendations 186
17.0 ENVIRONMENTAL AWARENESS PLAN 186
18.0 UNDERTAKING 187
19.0 NEXT STEPS IN THE EIA PROCESS 187
20.0 REFERENCES 187

TABLES

Table 2-1: Contact details of environmental assessment practitioner 3
Table 2-2: Details of area applied for 4
Table 2-3: Listed Activities applied for in terms of EIA Regulations of 2014 5
Table 5-1: Air enrichment alternatives 35
Table 5-2: Syngas desulphurisation alternatives 35
Table 7-1: Average Monthly Temperature in Project Area 44
Table 7-2: Annual Average Evaporation in Project Area 45
Table 7-3: Precipitation Data Summary 45
Table 7-4: Measuring points 49
Table 7-5: Pre-project noise levels at measuring points 52
Table 7-6: Coal properties 55
Table 7-7: Soil characteristics -preferred and alternative power plant sites 56
Table 7-8: Soil types along the preferred power line and pipeline routes 59
Table 7-9: Soil chemistry 59
Table 7-10: Surface water features relevant to project area 64
Table 7-11: Nearest DWAF flow monitoring station 67
Table 7-14: Available rainfall data in project area 68
Table 7-15: 24 hour storm rainfall depths for Welkom Sandvet 69
Table 7-16: Monthly open water evaporation from station C4E009 and WR90 69
Table 7-17: Flow monitoring stations in the Palmietkuilspruit area 70
Table 7-18: Water Quality Monitoring stations in vicinity of Palmietkuilspruit 72
Table 7-20: Subcatchment characteristics used in the flood estimation methods 73
Table 7-21: Summary of hydrocensus data 78
Table 7-22: Summary of field geochemical parameters 79

Table 7-23: Analytical results - inorganics 79
Table 7-26: Mammalian species known to occur in the region of the project area 87
Table 7-27: Evaluation of power line and water pipeline route alternatives 89
Table 7-28: Demographic data for Lejweleputswa District Municipality 91
Table 7-29: Employment Profile for Lejweleputswa District Municipality in 1996 and 2004 92
Table 7-30: Cultural and heritage resources in vicinity of project area 94
Table 11-1: South African Ambient Air Quality Standards for Criteria Pollutants 108
Table 11-2: Subcategory 1.5 110
Table 11-3: Subcategory 3.1 110
Table 11-4: Subcategory 3.2 112
Table 11-5: Subcategory 3.6 112
Table 11-6: Emissions guidelines for natural gas reciprocating engines (mg/Nm3) 112
Table 11-7: Ambient Air Quality Standards (µg/m^3) 113
Table 11-8: Summary of acute and chronic health effects associated with exposure to the primary pollutants (WHO, 2004) 113
Table 11-9: Composition of UCG gas according to literature, compared with field measurements 115
Table 11-10: Results from the dispersion simulations 119
Table 11-14: Sound pressure levels of construction machinery 129
Table 11-15: Distance of noise sensitive areas from power plant site 130
Table 11-16: Calculated noise levels at NSAs – gas turbine alternative 132
Table 11-17: Calculated noise levels at NSAs – gas engine alternative 133
Table 11-19: Dimensions of clean runoff diversion channels to convey the 1:50 year flood peak 139
Table 11-20: Water Quality variables to be monitored 142
Table 11-21: Summary of packer test results 144
Table 11-22: Calibrated hydraulic conductivity values 148
Table 11-23: Changes of hydraulic properties for layers affected during UCG 149
Table 11-24: Personnel Complement 153
Table 12-1: Environmental Impact Assessment Matrix for the construction phase of the proposed underground coal gasification project near Theunissen 156
Table 12-2: Environmental Impact Assessment Matrix for operational phase of the proposed underground coal gasification project near Theunissen 157
Table 12-3: Environmental Impact Assessment Matrix for the decommissioning and rehabilitation phase of the proposed underground coal gasification project near Theunissen 159
Table 16-1: Latent environmental impacts/risks 184
Table 16-2: Cost of mitigation of latent environmental impacts 185

FIGURES

Figure 2-1: Height of collapse as a function of span width and rock mechanical properties of drill cores 7

Figure 2-2: Location of Africary prospecting rights and preferred target area for UCG project 9
Figure 2-3: Location of proposed Africary UCG and gas-fired power generation project near Theunissen 10
Figure 2-4: Schematic illustration of the proposed UCG project 11
Figure 2-5: Flow diagram of the proposed UCG and Syngas Processing Facility 13
Figure 2-6: Interior of a typical gas engine power plant (Wärtsilä, Finland) 14
Figure 2-7: Schematic site layout 17
Figure 3-1: ESHIA process 23
Figure 5-1: Alternative UCG target areas and infrastructure footprints 33
Figure 5-2: GE Flex efficiency 60 NG Turbine 34
Figure 5-3: Wastewater treatment options considered 36
Figure 5-4: Schematic flow sheet for super critical water oxidation 37
Figure 5-5: Alternative power line and water pipeline routes varying in length from 11 to 16.7 km 38
Figure 7-1: Location of the WELKOM and VIRGINIA – MUN meteorological stations in relation to the proposed UCG Facility 43
Figure 7-2: Long term average maximum, minimum and mean temperatures for Welkom (1964-1990) and Virginia (1961-1990) 44
Figure 7-3: Long term average monthly rainfall for Welkom (1964-1990) and Virginia (1961-1990) 45
Figure 7-4: Modelled wind rose and wind frequency distribution at the power plant site for the period 2008 to 2012 46
Figure 7-5: Modelled diurnal wind rose and wind frequency distribution at the power plant site for the period 2008 to 2012 47
Figure 7-6: Modelled seasonal wind rose and wind frequency distribution at the power plant site for the period 2008 to 2012 48
Figure 7-7: Noise sensitive areas and measuring points 51
Figure 7-8: Topography of the Free State (DEAT, 2009) 53
Figure 7-9: Cross section of the Karoo Super Group geology 54
Figure 7-10: Soil characterisation - preferred and alternative power plant sites 57
Figure 7-11: Soil characterisation along preferred power line and pipeline route 58
Figure 7-12: Land capabilty and land use at preferred and alternative power plant sites 61
Figure 7-13: Land capability map - power line and pipeline route 62
Figure 7-14: Pre-project land use map - power line and pipeline route 63
Figure 7-15: Base Map of Middle Vaal Water Management Area (DWAF, 2004) (red square indicates project area) 65
Figure 7-16: Evaporation data for station C4E009 Zeebrugge at Sand-Vet Sentrum 69
Figure 7-17: Box plot for flow monitoring station C4H016 Sand River at Bloudrif 70
Figure 7-18: Flow and water quality monitoring stations in vicinity of Palmietkuilspruit 71
Figure 7-19: Catchment boundary of Palmietkuilspruit for floodline determination 74
Figure 7-20: Flood lines for the Palmietkuilspruit in the project area 75
Figure 7-21: Hydrocensus boreholes in the vicinity of the project area 77

Figure 7-22: View of Palmietkuilspruit, with farmhouse in the background 81
Figure 7-23: Small farm dam on alternative power plant site 82
Figure 7-24: Roads and Sand-Vet Irrigation Infrastructure 82
Figure 7-25: Sand-Vet Irrigation Scheme concrete canals traverse the project area 83
Figure 7-26: Biomes of South Africa (NBI, 1997) 83
Figure 7-27: Map of the different vegetation types near the study area (Van Aardt, 2010) 84
Figure 7-28: Dominant vegetation units (AZa 5): Highveld Alluvial Vegetation (pink) and (Gh 10): Vaal-Vet Sandy Grassland (orange) 85
Figure 7-29: SAR Class 16DA 850 plinthed in Theunissen, 29 May 2005 93
Figure 7-30: Cultural and heritage resources – at site and along route 95
Figure 7-31: Cultural and heritage resources near power plant site 96
Figure 7-32: Typical flat topography of site (top) and gently rolling topography of study area directly to the north (bottom) 98
Figure 7-33: The Palmietkuilspruit is not visually prominent in the landscape 99
Figure 7-34: Areas from which power plant will be visible 101
Figure 9-1: Mitigation Hierarchy adapted from BBOP (2009) 103
Figure 11-1: Land use and sensitive receptors in the vicinity of the proposed power plant site 116
Figure 11-2: Simulated CO emissions during venting (1 hour average) 121
Figure 11-3: Simulated CO emissions during flaring (1 hour average) 121
Figure 11-4: Simulated NO_x emissions during flaring (modelled as NO_2, 1 hour average) 122
Figure 11-5: Simulated SO_2 emissions during flaring (1 hour average) 122
Figure 11-6: Simulated CO emissions released via the gas engine exhaust (1 hour average) 123
Figure 11-7: Simulated CO emissions released via the gas engine exhaust (8 hour average) 123
Figure 11-8: Simulated gas engine NO_x emissions at IFC standard of 32 g/s (modelled as NO_2, 1hour average) 124
Figure 11-9: Simulated gas engine NOx emissions at the IFC standard of 32 g/s (modelled as NO_2, annual average) 124
Figure 11-10: Simulated gas engine SO2 emissions simulation (1hour average) 125
Figure 11-11: Simulated gas engine SO2 emissions simulation (24 hour average) 125
Figure 11-12: Simulated gas engine SO2 emissions simulation (annual average 126
Figure 11-13: Calculated noise contours for power plant based on gas turbines 131
Figure 11-14: Calculated noise contours for power plant based on gas engines 133
Figure 11-15: Proposed stormwater management system layout 138
Figure 11-16: Water Balance schematic for Africary UCG project 141
Figure 11-17: Positions of exploration boreholes 145
Figure 11-18: Conceptual Hydrogeological Model 146
Figure 11-19: Steady state calibration - computed vs. measured water levels 148
Figure 15-1: Composite map showing project components and sensitive areas 167

APPENDICES

APPENDIX A
Database of Potentially Interested and Affected Parties

APPENDIX B
Letter of invitation to all stakeholders informing them of the availability of the Final Scoping Report and the date of the Public Meeting

APPENDIX C
The advertisement published in two local newspapers

APPENDIX D
List of Registered I&APs

APPENDIX E
Site Notices

APPENDIX F
Comment and Response Report

APPENDIX G
South African Water Quality Guidelines

APPENDIX H
Specialist Studies

APPENDIX I
Document Limitations

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Explanation
AEL	Atmospheric Emission Licence
Al_2O_3	Aluminium oxide
BEE	Black Economic Empowerment
BPG	Best Practice Guideline
CARA	Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983)
CO	Carbon monoxide
CCGT	Combined Cycle Gas Turbine
CH_4	methane
CRIP	Controlled Retractable Injection Point
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DWA (DWAF)	Department of Water Affairs (formerly Department of Water Affairs and Forestry)
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
FS DETEA	Free State Department of Economic Development, Tourism and Environmental Affairs
GDP	Gross Domestic Product
GGP	Gross Geographic Product
GNR	Government Notice Regulation
ha	Hectare
H_2	Hydrogen
IGCC	Integrated Gasification Combined Cycle
IDP	Integrated Development Plan
IPP	Independent Power Producer
I&APs	Interested and Affected Parties
IWUL	Integrated Water Use License
IWWMP	Integrated Water and Waste Management Plan
kV	Kilo Volt
LPG	Liquid Petroleum Gas
LoM	Life of Mine
LOX	Liquid Oxygen
MAE	Mean Annual Evaporation
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
mbgl	Metres below ground level
MR	Mining Right
MRA	Mining Right Application

Abbreviation	Explanation
MRB	Mineral Regulation Branch
MSDS	Material Safety Data Sheets
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002)
MW	Mega Watt
NEM:AQA	National Environmental Management: Air Quality Act, 2004 (Act 39 of 2004)
NEM:WA	National Environmental Management: Waste Act, 2008 (Act 59 of 2008)
NEMA	National Environmental Management Act, 1998 (Act 107 of 1998)
NWA	National Water Act, 1998 (Act 36 of 1998)
PPE	Personal Protective Equipment
PPP	Public Participation Process
PSA	Pressure swing adsorption
NO_3	Nitrate
ROM	Run of Mine
SANBI	South African National Biodiversity Institute
SANS	South African National Standards (previously SABS)
SLP	Social & Labour Plan
SRU	Sulphur Removal Unit
SO_4	Sulphate
SWMP	Storm Water Management Plan
TiO2	Titanium dioxide
UCG	Underground Coal Gasification
VSA	Vacuum swing adsorption
WMA	Water Management Area
WML	Waste Management Licence
WUA	Water Users Association
WUL	Water Use License

PART A
SCOPE OF ASSESSMENT AND ENVIRONMENTAL IMPACT ASSESSMENT REPORT

1.0 INTRODUCTION

1.1 Project Background

Africary Holdings (Pty) Ltd (Africary), as the overall project owner and project proponent, proposes to establish an underground coal gasification (UCG) project in the Free State. African Carbon Energy (Pty) Ltd was established in 2007 by former Sasol executives Johan Brand and Eliphus Monkoe as a BEE mining and minerals development company focusing on energy production in Southern Africa and abroad. The company has acquired prospecting rights for coal over an area of more than 300 square kilometres and has identified potential target areas for the establishment of a UCG project at a site located about 24 km north-north-west of Theunissen and 27 km south-south-west of Welkom in the Free State Province. See Figure 2-2. The company has expertise in mining, gasification and power generation project development, specifically based on UCG and conventional coal mining.

UCG is a process that unlocks the energy potential of deep coal that would otherwise go un-mined, by injecting air and water into the coal seam to produce a combustible gas mixture underground and delivering it to the surface. An independent power producer (IPP) will be established, which will build, own and operate a power plant and deliver the electricity to the national grid. Instead of producing power, the gas could also be piped to other industries and used to generate heat or to make liquid fuels and organic chemicals by processes such as those operated by Sasol.

The average annual selling price of Eskom electricity has risen from 41,76 c/kWh in 2010 to 127.32 c/kWh in 2015 and is set to rise further in the years to come, making power generation from gas produced by UCG competitive. Africary believes there is potential for viable UCG projects on its Theunissen coal resource and is in the process of finalising a bankable feasibility study for this first project.

1.2 Permitting History

Africary undertook an Environmental Impact Assessment (EIA) process during 2013 and 2014 in terms of the EIA Regulations GN R.543, GN R.544 and GN R.545, which commenced in June 2010. Pursuant to consultation with the Free State Department of Economic Development, Tourism and Environmental Affairs (DETEA), an environmental authorisation application for power generation and distribution was submitted to the national Department of Environmental Affairs (DEA) and an environmental authorisation application for the other activities listed in GN R.544 and GN R.545 was submitted to the DETEA in Maty 2013. During March 2014 the two departments agreed that the DEA would deal with the entire application.

On 2 September 2015 the DEA granted an integrated environmental authorisation (number 14/12/16/3/3/3/116) for all the listed activities applied for, to be undertaken on the areas indicated on Figure 5-1 and Figure 5-5. The authorisation included a waste management licence (WML). On 16 November 2015 the Lejweleputswa District Municipality granted a provisional Atmospheric Emissions Licence (number LDM/AEL/LCR/005).

On 30 November 2015 Africary submitted an application for a mining right on the areas where it held prospecting rights - see Figure 2-2. On 7 January 2016 the DMR informed Africary that, in terms of the 2014 EIA Regulations an application for environmental authorisation must also be submitted to the DMR at the same time as the application for a mining right and that the EIA process as set out in GN R.982, which commenced on 4 December 2014, must be followed.

During engagement with the DMR between December 2015 and February 2016, Africary understood that the Scoping Report and EIA/EMPr Report that were approved by the DEA would remain valid and could be used in the EIA process to be undertaken in terms of the 2014 EIA Regulations, but Africary would have to re-apply for a mining riaght and environmental authorisation, and the public participation process would have to be repeated.

Africary re-applied for a mining right and environmental authorisation on 26 February 2016, and thereafter notified all I&APs on the database, made the scoping report available for public comment and submitted the

Scoping Report dated September 2013 to the DMR on 15 July 2016. The DMR accepted the application on 2 June 2016 and acknowledged receipt of the Scoping Report on 5 August 2016.

In a letter dated 13 September 2016 the DMR refused the application and rejected the Scoping Report on the grounds that it did not conform to the template that was developed by the DMR after the commencement of the 2014 EIA Regulations.

Pursuant to further correspondence with the DMR, the Scoping Report was re-compiled in the DMR format and made available for public comment from 4 October to 3 November 2016. Apart from an update of the Comment and Response Report and the attachment of copies of the latest newspaper advertisements and letters to I&APs, it contained the same information as the report that the DEA had approved in April 2014.

After further engagement with the DMR, the pending MRA was withdrawn and a new MRA and application for environmental authorisation (AEA) were submitted on 2 December 2016. During a meeting with DMR officials on 14 December 2016, they agreed that the public consultation process undertaken from 4 October to 3 November 2016 would be valid and Aficary submitted the Scoping Report on the same day (14 December 2016).

The new MRA was accepted on 21 December 2016, and a new reference number (FS30/5/1/2/2/10034MR) was issued. The new AEA was accepted on 30 January 2017 and the reference number FS 30/5/1/2/3/2/1(10034) EM was issued.

2.0 PROPONENT AND PRACTITIONER DETAILS

2.1 Details of the proponent

The proponent is Africary Holdings (Pty) Ltd (hereafter referred to as Africary). For purposes of this EIA, the following person may be contacted at Africary:

Contact Persons	Elmar Roberg
Address	PO Box 10020 Secunda, 2302
Telephone	084 653 4937
Fax	086 672 3998
Cell phone	082 651 5138
E-mail	elmar.roberg@africary.com

2.2 Details of Environmental Assessment Practitioner

Africary appointed Golder Associates Africa (Pty) Ltd (GAA) as an independent Environmental Assessment Practitioner (EAP) to undertake the Environmental Impact Assessment (EIA) that is required to support the application for a MR, EA, WML, AEL and WUL.

Golder Associates Africa is a member of the world-wide Golder Associates group of companies, offering a variety of specialised engineering and environmental services. Employee owned since its formation in 1960, the Golder Associates group employs more than 6 000 people who operate from more than 160 offices located throughout Africa, Asia, Australasia, Europe, North America and South America. GAA has offices in Midrand, Pretoria, Florida, Durban, Rustenburg, Cape Town, Maputo and Accra. GAA has more than 300 skilled employees and is able to source additional professional skills and inputs from other Golder offices around the world.

GAA has no vested interest in the proposed project and hereby declares its independence as required by the EIA Regulations. For purposes of this EIA, the persons listed in Table 2-1 may be contacted at Golder.

Table 2-1: Contact details of environmental assessment practitioner

Contact Persons	Etienne Roux	Antoinette Pietersen
Purpose	Technical	Public Participation
Address	P O Box 6002 Halfway House 1685	P O Box 6002 Halfway House 1685
Telephone	011 254 4970	011 254 4805
Fax	011 315 0317	011 315 0317
Cell phone	082 774 2045	083 280 5024
E-mail	Eroux@golder.co.za	Apietersen@golder.co.za

2.2.1 Expertise of environmental assessment practitioners

2.2.1.1 Qualifications

Etienne Roux holds an MSc degree in physical chemistry from the University of Pretoria (1966) and an MBL degree from the University of South Africa (1974). He also completed a Development Programme in Labour Relations at the University of South Africa (1984). He has 53 years' experience in mining and industry, the last 22 years being in environmental impact assessment and auditing processes.

Antoinette Pietersen holds a BA (Hons) in psychology from the Potchefstroom University for Christian Higher Education. She has more than 18 years' experience in the design, facilitation and management of public participation processes to local and international standards. She is a past President of the Southern African Affiliate of the International Association for Public Participation (IAP2) and an internationally certified trainer in public participation processes.

2.2.1.2 Summary of past experience

Etienne Roux

1962-1966: African Explosives and Chemical Industries Ltd, Modderfontein – research and development work on industrial electrochemical processes;

1967-1993: Foskor Ltd, Phalaborwa – analytical chemistry, systems analysis, research and development, geological exploration, mining, production, tailings storage, environmental management, strategic corporate planning;

1993-2005: Industrial Development Corporation: Responsible for developing corporate environmental, health and safety policy and capability, managing environmental aspects of IDC's larger industrial, mining and agricultural projects, managing remediation programs on polluted sites, designing and implementing an EHS risk assessment methodology specifically for a financial institution and overseeing its application. Participated in more than 50 EIAs within South Africa and seven other African countries, several with involvement from World Bank, IFC, European Investment Bank, African Development Bank, Kreditanstalt für Wiederaufbau, provided environmental guidance on IDC's investment decisions and served as director on boards of two IDC subsidiaries.

2006 – Present: Golder Associates Africa (Pty) Ltd – Has undertaken more than 20 complete EIAs, 5 environmental audits and several environmental due diligence investigations.

Antoinette Pietersen

1995-1996: Department of Water Affairs and Forestry –Communications Officer responsible for internal and external newsletters, preparation of media releases and radio interviews and event coordination, including press conferences and ministerial functions.

1996 – Present: Public participation practitioner at environmental consultancies Strategic Environmental Focus, Ferret Mining and Environmental Services and Golder Associates Africa (Pty) Ltd.

2.3 Description of the property

Africary has applied for a mining right on the area where it holds prospecting rights (see Figure 2-2) and has applied for environmental authorisation to undertake the UCG project described in section 2.5 of this report on the area indicated in Table 2-2 and on Figure 2-3.

Table 2-2: Details of area applied for

Farm	Surveyor General Codes	Listed Owner
Palmietkuil 548	F03300000000054800000	Agricary Farming (Pty) Ltd
	F03300000000054800001	

2.4 Locality map

The farm Palmietkuil 548 is located in the Magisterial District of Welkom in the Free State Province, about 22 km south-west of the city of Welkom and 27 km north-west of the town of Theunissen. Refer to Figure 2-3.

African Carbon Energy (Pty) Ltd (Africary) has applied for a mining right and intends first extraction on portions 0 and 1 of the farm Palmietkuil 548. In terms of the new EIA Regulations GN R.982/983/984/985 that commenced on 8 December 2014, an application for a mining right triggers an application for environmental authorisation, which must be supported by a scoping and impact assessment process and which must also be submitted to the DMR.

An application for environmental authorisation for listed activities associated with the utilisation of coal by means of underground coal gasification on Palmietkuil 548 was submitted to the Department of Mineral Resources on 13 May 2016 and re-submitted on 4 October 2016.

2.4.1 Magisterial District and relevant Local Authority

Palmietkuil 548 is located in the Lejweleputswa District Municipality and falls within the jurisdiction of the Welkom Magisterial District.

2.4.2 Landowners and use of immediately adjacent land

The proposed project area is surrounded by mainly agricultural activities. The farm Palmietkuil 548 belongs to Agricary Farming (Pty) Ltd.

2.5 Description and Scope of the Proposed Overall Activity

Africary has acquired the coal rights to the Theunissen coal field and is proposing to develop underground coal gasification (UCG) as a means of exploiting these coal reserves. AgriCary Farming has acquired the surface rights to farms strategically located above these reserves. AgriCary Farming will continue with agricultural activities on these farms while providing access to Africary to exploit the coal and process the raw gas from the UCG wells.

The current project, as described in this report, will involve gasification of about 5 million tons of coal over 20 years under an area of about 150 hectares and will generate 50 – 60 MW (nett) clean electricity to the grid from a de-rated installed gross capacity of ±77 MW, but Africary will apply for a mining right over the entire exploration right area of more than 300 square kilometres. If the current project proves to be commercially viable, gasification may be expanded to a larger area and the power generation capacity may also be expanded.

The optimal size of a power generation plant based on underground coal gasification is estimated to be in the region of 450 to 700 MW. The larger plant could be built at the same location as the 50 – 60 MW plant or at another site within the ~300 km^2 area. Pipelines of up to 20 km in length would transport the injection gases and the synthesis gas between the power plant site and the gasification areas. The larger project will require its own EIA, with specialist studies focused on the affected areas.

The project is located in the savannah grasslands of the Free State in the central region of South Africa. The grasslands have largely been converted to agricultural fields. Nearby towns include Welkom, Virginia, Theunissen and Bultfontein. Several national roads exist in the area, many of which interconnect these

towns. The R30 passes within about 12 km to the east of the proposed site and a regional tar road passes through the proposed Africary UCG project area located on the farm Palmietkuil. Theunissen, Welkom and Virginia are all approximately 25km from the proposed project area.

Africary has considered gas turbines and reciprocating engines as drivers for the power generator, with reciprocating engines being the preferred choice. See section 5.3 for a discussion of the alternatives.

The gas turbine / gas engine power plant will be small, with the ancillary infrastructure consisting of water and power reticulation, a security kiosk, offices and a workshop occupying more space than the power generating turbine or gas engines itself. The personnel complement is estimated at about ten people. The proposed development will include:

- Underground coal gasification of a roughly 100 ha coal footprint (±5 million tons of coal);
- Surface infrastructure footprint of about 3 ha;
- Infrastructure to include gas cleaning, power generation, waste handling (but not on-site disposal), administration and maintenance;
- Approximately ten kilometre Eskom distribution line (132 kV) connecting to an overhead line connecting to a substation adjacent to Beatrix Gold Mines;
- Water supply pipeline from Sedibeng Water, connecting to the supply line close to Beatrix Gold Mine or utilizing the existing Sand-Vet Water Users Association canal supply on the farm; and
- Africary will store approximately 1 000 m^3 of diesel and 200 m^3 of liquid oxygen (LOX), LPG and methane on site but no syngas. LOX will be stored in a bunded area in doubled-walled vessels with double-walled piping.

2.5.1 Listed and specific activities

The activities listed in Table 2-3 were applied for.

Table 2-3: Listed Activities applied for in terms of EIA Regulations of 2014

Name of Activity	Aerial extent in ha	Listed Activity Number	Listing Notice
Activities submitted to the Department of Mineral Resources (DMR) in terms of Section 24C (2) (d) (i) of the NEMA			
The stormwater management system will require the development of- (ii) runoff collection channels exceeding 100 square metres in size; (iv) pollution control dams, where the dams, including infrastructure and water surface area, exceeds 100 square metres in size; (vi) bulk stormwater outlet structures exceeding 100 square metres in size;	3	12	GN R.983, 4 December 2014
The proponent has applied for a mining right	600	17	GN R.984, 4 December 2014
The project requires an atmospheric emission licence	3	28	GN R.984, 4 December 2014

2.5.2 Description of the activities to be undertaken

2.5.2.1 Underground coal gasification

The coal seams in the project area occur at depths ranging from 320 to 500 metres (m) below the surface and have an average thickness of 3.2 m. See section 7.5 for a more detailed description of the geology of the project area.

UCG is an *in-situ* process that converts coal deep underground into combustible gas, which is extracted for beneficial use *via* boreholes. UCG is a high-extraction mining method utilising at least two boreholes (also referred to as wells) that are drilled horizontally into the coal seam parallel to one another. Ambient air or air that has been enriched with oxygen, is delivered into the coal seam *via* one or more boreholes (the injection wells) and the coal is ignited in order to start the gasification process, which may also be thought of as a thermo-chemical mining process. The burning front results in high temperatures (typically from 700 ^{o}C to 900 ^{o}C) that cause the coal ahead of the front effectively to re-form into gas. Groundwater, augmented by water added to the air injection borehole if necessary, reacts with the carbon in the coal to form a combustible gas mixture of mainly carbon monoxide (CO), hydrogen (H_2) and methane (CH_4).

This coal re-formation takes place at high temperature, which is created by the gasification front, and high pressure, which is caused by the build-up of hot gases in the gasifier deep underground. It is to be noted that the pressure in the gasifier will always be lower than the hydraulic head of the groundwater at the depth of the coal seam, which will cause the groundwater to flow very slowly towards the gasifier. The gas mixture is extracted *via* another borehole (the production well). UCG can be applied to coal resources that are otherwise unprofitable or technically difficult to extract by traditional mining methods. The gas produced by this method can be used as a chemical feedstock or as fuel for power generation. Ash and other remnants of the coal remain underground in the gasifier.

The gasifier will fill up with rubble over time by the slow collapse of the rock layers immediately above it, a process known as goafing. The effects at the surface depend on the depth of the gasifier below the surface, its dimensions and the characteristics of the overlying rock layers.

An analysis of conditions at the UCG target area shown on Figure 5-1 by examination of drill cores (van der Merwe , J N;, 17 January 2014) concluded that:

- For a gasification chamber up to 100 m in diameter, only local roof collapse will occur and the goaf will form to a height of 30 m;
- From 100 m to 300 m advance, the collapse zone will increase in height to 100 m and the void volume in the goaf will decrease from 6% to 3%;
- At 300 m advance, the full overburden will collapse and with further advance, the collapse will follow the combustion front with periodic overhangs of the immediate roof;
- Beyond 300 m, surface subsidence of about 1.0 to 1.2 m is expected to occur and the goaf will be compacted, with the void volume decreasing to less than 1%.

These findings are illustrated in Figure 2-1. The UCG target area has a footprint of about 1011 m x 530 m.

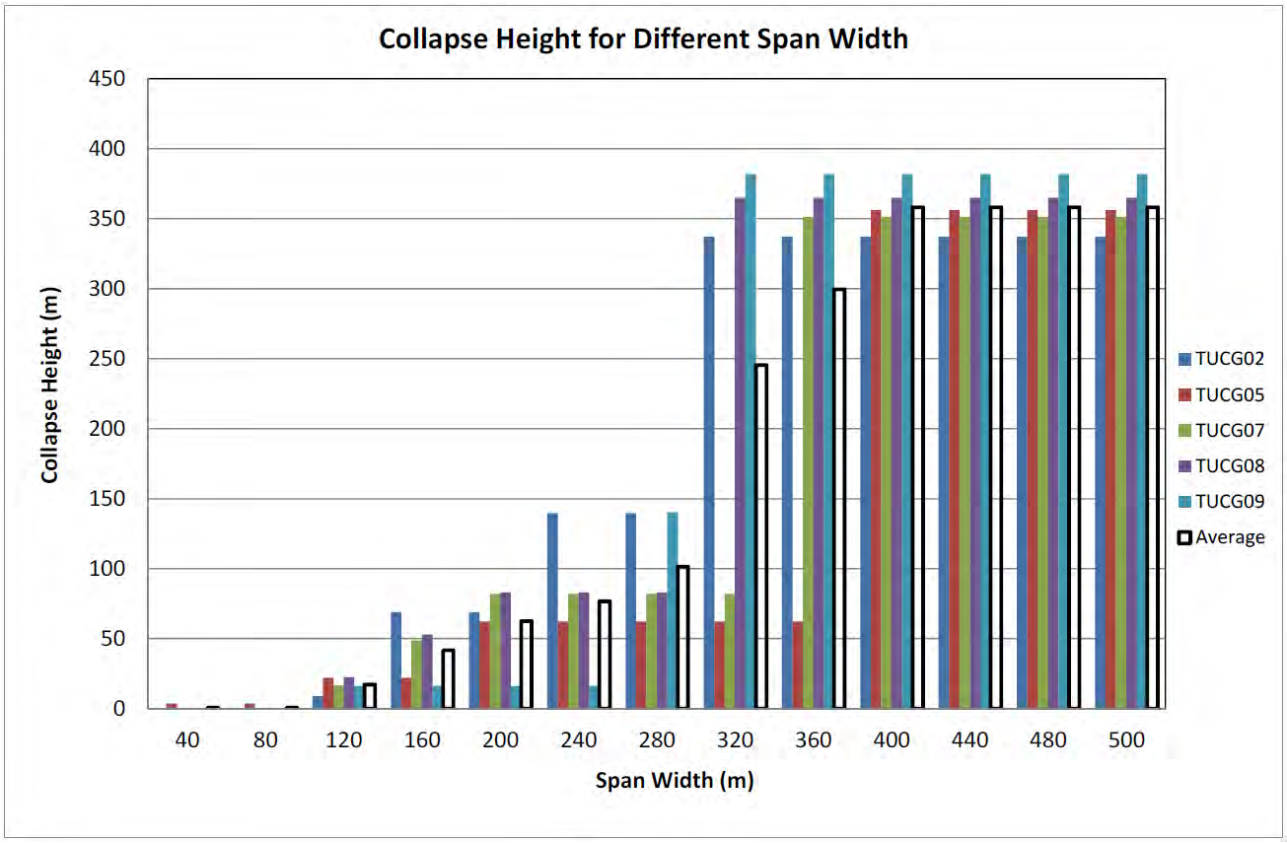


Figure 2-1: Height of collapse as a function of span width and rock mechanical properties of drill cores

UCG has much lower environmental and safety impacts than traditional coal mining and power generation. This technology eliminates mine safety issues, surface damage, stockpiles of overburden and discards coal, and solid waste discharge like ash dumps, and has lower sulphur dioxide (SO_2), nitrogen oxide (NOx) and particulate (PM_{10}) emissions.

The earliest recorded mention of the idea of underground coal gasification was in 1868. The first successful test was conducted by the Donetsk Institute of Coal Chemistry on 24 April 1934 at Lysychansk in the Soviet Union and a local chemical plant began using the gas commercially in 1937. A number of UCG projects were established across the world after the Second World War and UCG is now recognised globally as a technically and economically viable method of accessing deep, otherwise unrecoverable coal reserves, both on- and offshore. (http://en.wikipedia.org/wiki/Underground_coal_gasification, 2013) It has been estimated that UCG technology could effectively double the energy reserves represented by the world's coal deposits.

Recent examples include:

(i) the Belgo-German UCG trial at Thulin (860m depth), Belgium, 1981-1987;

(ii) the CCUCG Steeply Deeping trial at Rawlins (500m depth), Wyoming, USA, 1994-1996;

(iii) the European UCG trial at El Tremedal (600m depth), Spain, 1991-1997;

(iv) the Swan Hills Synfuels trial (1,400m depth), Alberta, Canada, 2007-2012;

(v) Rocky Mountain trials, Wyoming, USA - Rawlins (1979 - 1981) and Hanna (1986 – 1988);

(vi) Solid Energy's Huntly, New Zealand trial in 1994 and 2013;

(vii) Trial at WIDCO mine in Centralia, Washington State, USA (approx. 100m) 1981 – 1982;

(viii) China has conducted 16 trials since the late 1980s; AND

(ix) India's ONGC is pursuing UCG in one lignite block in the state of Gujarat.

(x) Eskom in South Africa has had an operating UCG plant since 2007 feeding into the Majuba powerstation.

(xi) Carbon Energy in Australia has an operating UCG plant and 4 gas engines and was selling 15 MWe into the grid by 2012.

(xii) Linc Energy in Australia has had an operating UCG plant since 2001 and produced 25 barrels per day of diesel and jet fuel in 2012.

According to the Zeus Development Corporation, a market development research firm based in Houston, Texas, more than 60 UCG projects are in development around the world. (http://en.wikipedia.org/wiki/Underground_coal_gasification, 2013).

In the last few years there has been significant renewed interest in UCG and the technology has moved forward considerably. (http://www.worldcoal.org/coal/uses-of-coal/underground-coal-gasification/, 2014)

- China has about 30 projects in different phases of preparation that use underground coal gasification.
- India plans to use underground gasification to access an estimated 350 billion tonnes of coal. In 2007 India compiled a 93-page status report on underground coal gasification that highlighted interest from many of the country's biggest companies.
- South African companies Sasol and Eskom both have UCG pilot facilities planned or operating for some time, generating valuable information.

Demonstration projects and studies are also currently under way in a number of countries, including the USA, Western and Eastern Europe, Japan, Indonesia, Vietnam, India, Australia and China, with work being undertaken by both industry and research establishments.

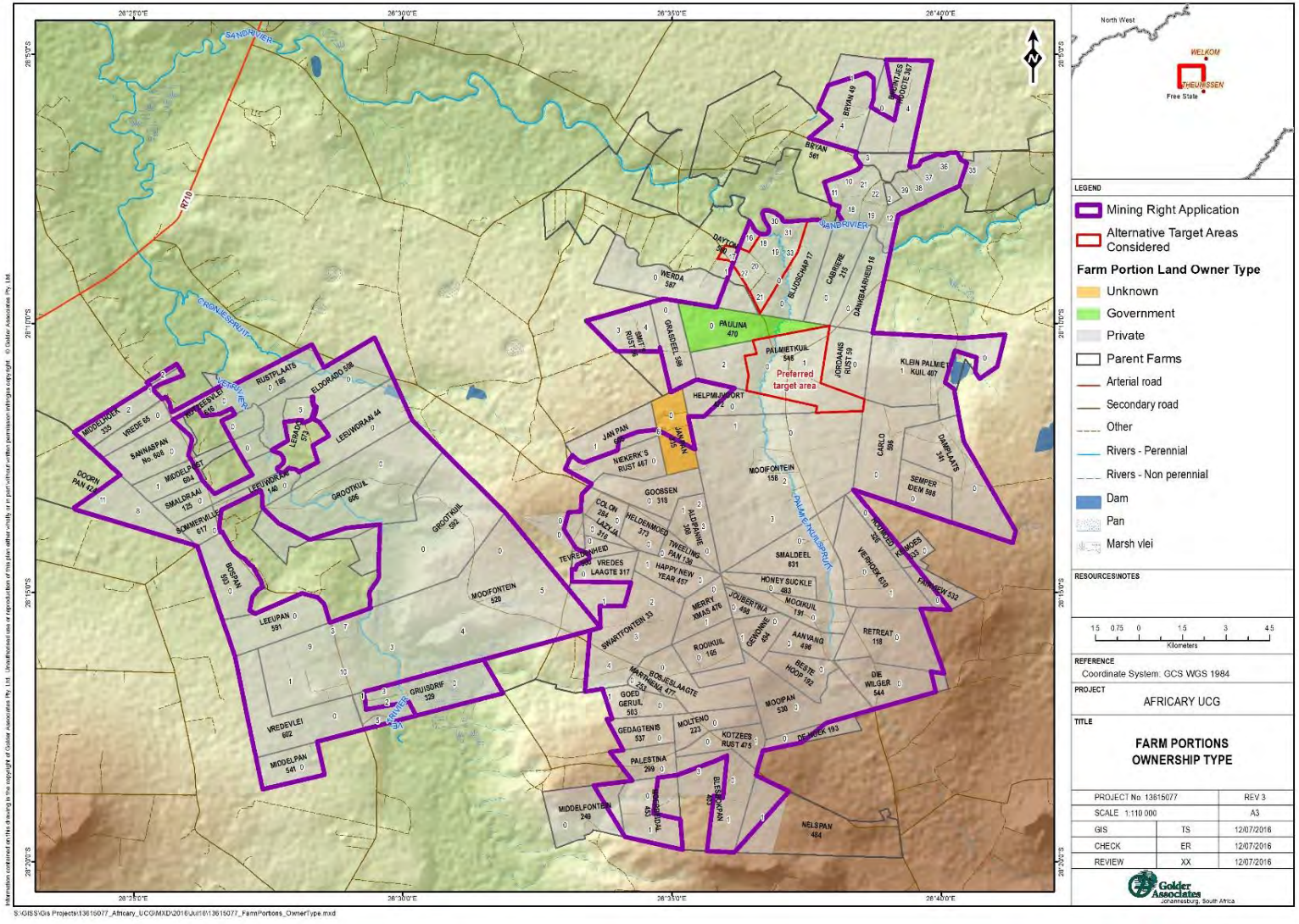


Figure 2-2: Location of Africary prospecting rights and preferred target area for UCG project

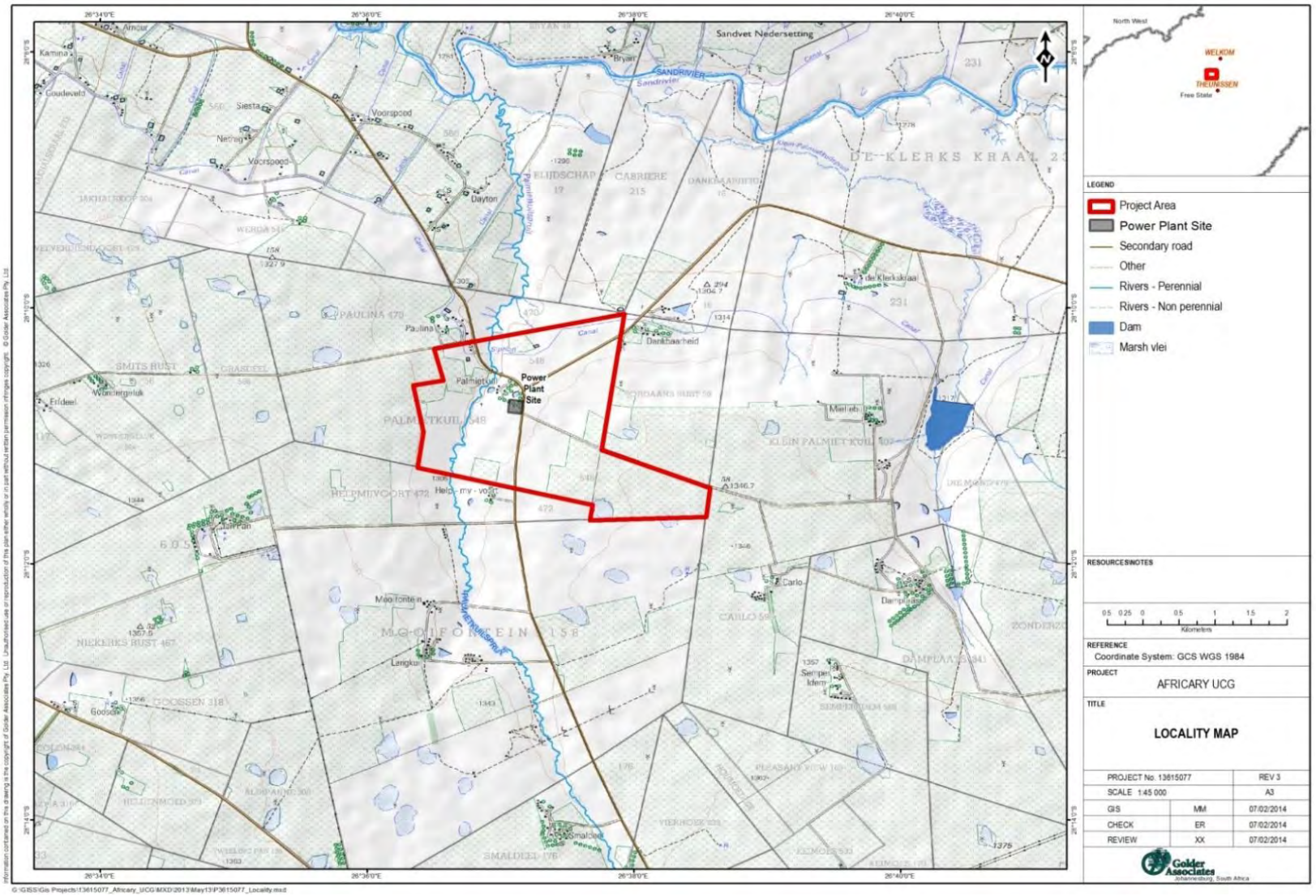


Figure 2-3: Location of proposed Africary UCG and gas-fired power generation project near Theunissen

The proposed project will use the UCG process to extract the energy value of the coal in a usable form as synthesis gas (syngas). The UCG process that Africary proposes to use on the Free State coal deposits is illustrated in Figure 2-4. In earlier UCG projects new injection and production wells would be drilled when the coal between the two wells had been exhausted and the old wells would be sealed. Modern directional drilling techniques have made it possible to drill parallel wells along the coal seam, thereby reducing the number of boreholes and the frequency with which the wellheads need to be moved.

The well head equipment is standard oil/gas well equipment according to the internationally recognized API specifications and safety standards and is well proven world-wide. All UCG designs try to achieve the most economical method of injecting the oxidant into a coal seam. The UCG technology proposed for this project is referred to as Controlled Retractable Injection Point (CRIP). Using a directionally drilled injection well, the oxidant mix is injected into an underground coal seam where a cavity is formed by removing the carbon from the coal. The cavity acts like a very efficient underground gasifier, consuming and converting the coal in-situ and producing energy-carrying gas which is extracted *via* the production well.

Thermodynamic modelling has been undertaken using data from boreholes near the site as a basis for the feed design. Further exploration is planned although the indication is that the presented data are sufficient for design purposes. Further exploration drilling will be undertaken to confirm the coal quality of the chosen UCG site.

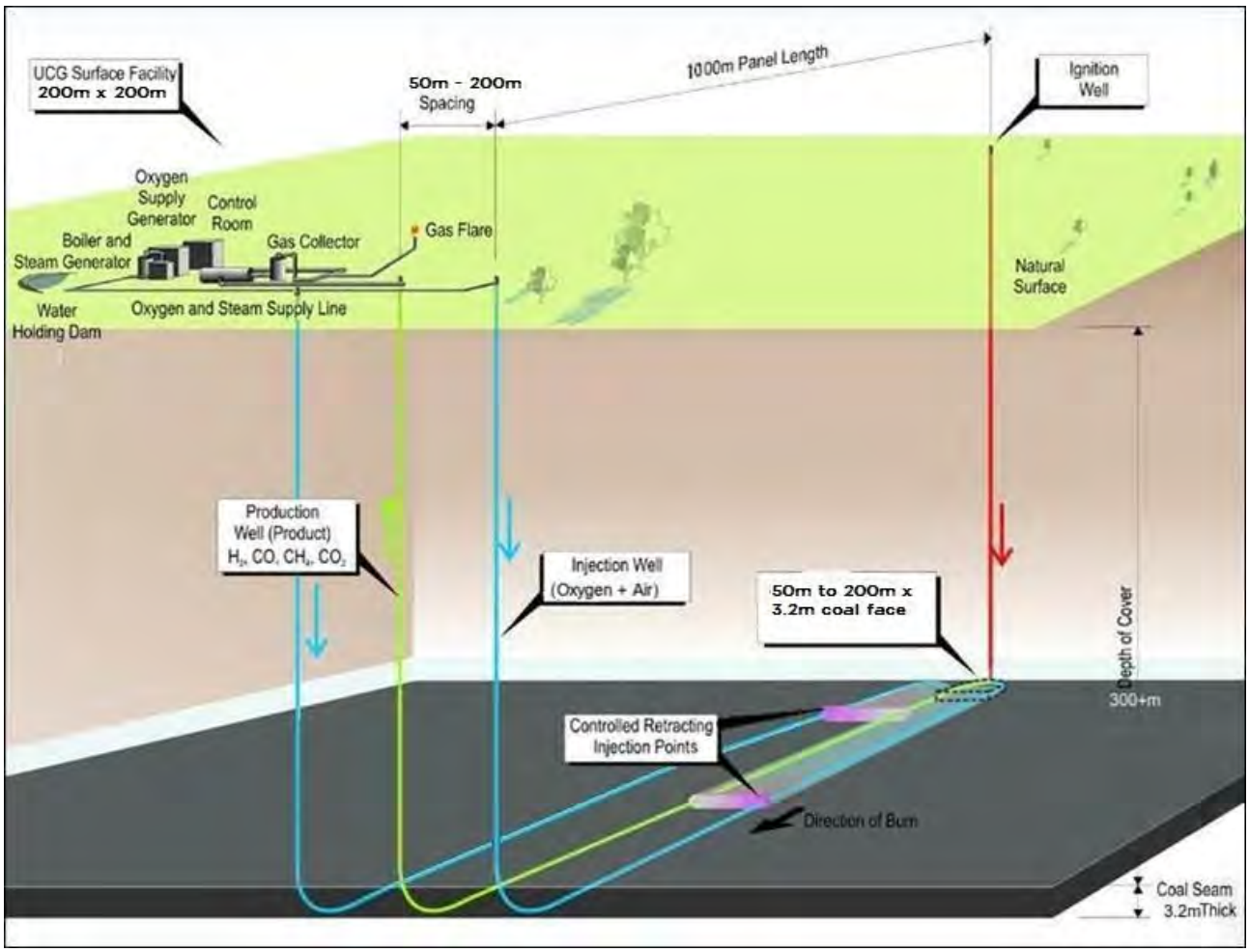


Figure 2-4: Schematic illustration of the proposed UCG project

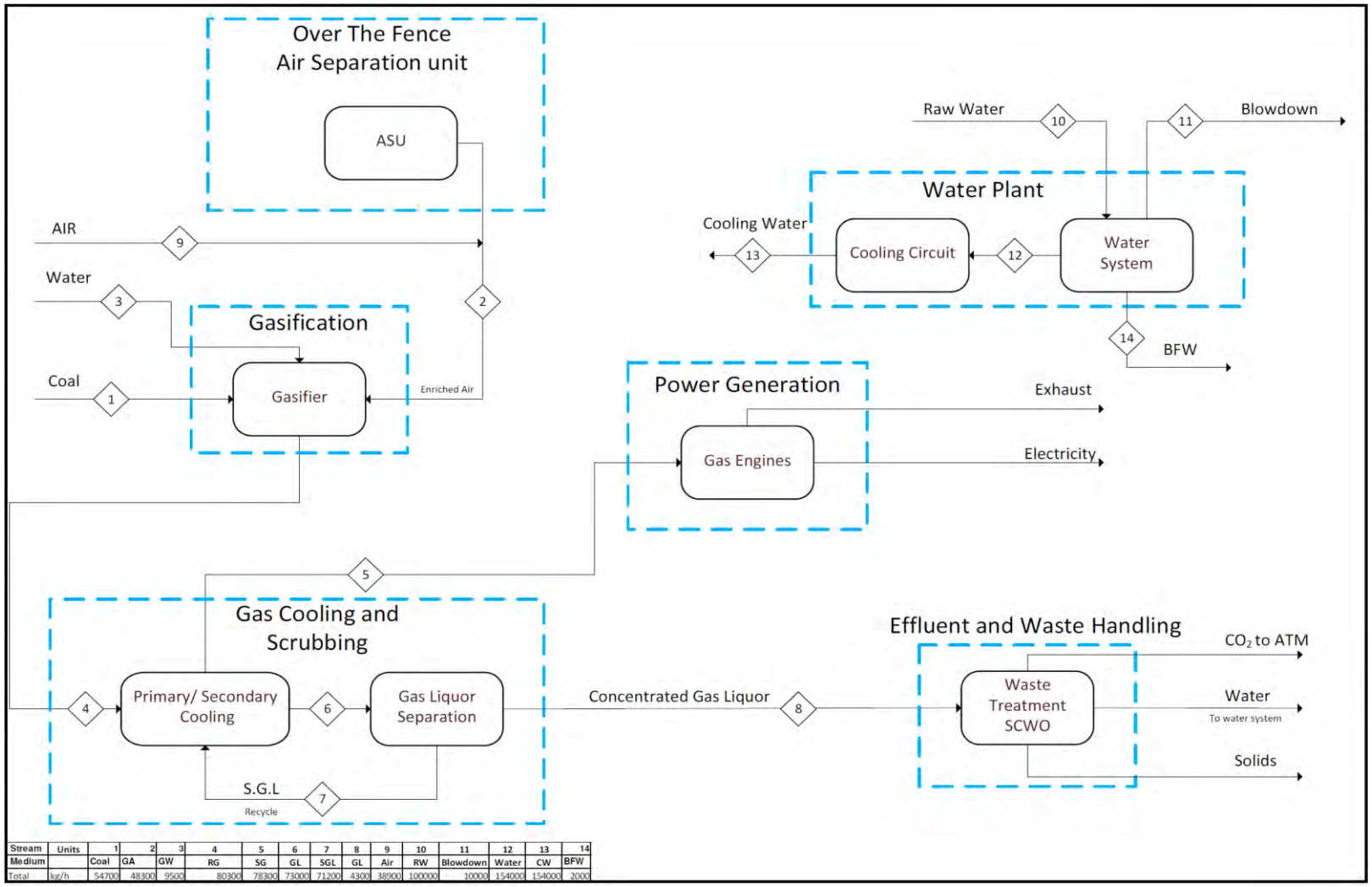
2.5.2.2 Syngas processing and power generation

The ash (non-combustible constituents) remains underground in the gasifier after the coal has been gasified. The raw gas will be cooled on surface to remove water, particulate matter and higher hydrocarbons. If gas turbines are used, sulphur will be removed from the cooled gas as a saleable by-product, but sulphur removal is not necessary if reciprocating gas engines are used (preferred alternative – see section 5.3).

An independent power producer (IPP) will use the resulting syngas to generate electricity (50 – 60 MW_e nett) as illustrated in the flow scheme below (Figure 2-5). See Figure 2-6 for an illustration of a power generating plant based on gas engines produced by Wärtsilä of Finland.

The footprint of the above ground gas processing facility and power plant will be about 3 hectares (ha) and it will include:

- Infrastructure required for the gasification process;
- Above ground gas preparation facilities;
- Some 18 reciprocating gas engines (preferred alternative – see section 5.3) or one gas turbine;
- Electrical power generators; and
- A ±10 km power line connecting the power station to the national grid.



Stream	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Medium		Coal	GA	GW	RG	SG	GL	SGL	GL	Air	RW	Blowdown	Water	CW	BFW
Total	kg/h	54700	48300	9500	80300	78300	73000	71200	4300	38900	100000	10000	154000	154000	2000

Figure 2-5: Flow diagram of the proposed UCG and Syngas Processing Facility

Figure 2-6: Interior of a typical gas engine power plant (Wärtsilä, Finland)

The syngas processing plant will start at the outlet of the production well and continue up to the feed to the electricity generation block, including gas liquor separation (Coetzee, W; Stols, C R;, May 2013). It will include the following aspects (Figure 2-5):

- Raw gas cooling - primary gas cooling in a quench column where gas is cooled from approximately 200°C in the column and air cooler combination and secondary gas cooling in shell and tube heat exchangers to condense the remaining gas liquor and cool the feed to approximately 35°C; and
- Gas liquor separation - the gas liquor is separated into a bottoms concentrate and a stripped gas liquor. The stripped gas liquor is recycled back to the quench column and the bottoms concentrate is sent to waste treatment for disposal.

2.5.2.3 Electricity distribution

The project will include a ≈10km 132 kV Eskom distribution line that will connect to a over-head line connecting to a substation adjacent to Beatrix Gold Mine. The nett electricity generated by the facility will be sold to Eskom and distributed to consumers *via* the national power grid.

2.5.2.4 Establishment of utilities and ancillaries

The utilities and ancillaries that will be established within the facility are divided into four systems and include:

- Gaseous utilities;
- Aqueous utilities;
- Fuels; and
- Catalysts and chemicals.

2.5.2.4.1 Gaseous utilities

The plant will require air for instrument air and pneumatically operated equipment. This will be provided by the process air compressor with suitable filtration and drying to meet the required specifications. It is estimated that this requirement will be 100 m_n^3/h.

Enriched air will have an oxygen content of approximately 50% which is blended with compressed air to before injection into the well.

Utility nitrogen (95% pure low pressure nitrogen) for purging and blanketing purposes will be supplied from the oxygen enrichment plant. This will be a small intermittent use. The option of importing liquid nitrogen and liquid oxygen will also be investigated.

Utility steam will be provided by a gas-fired utility boiler and the expected requirement is 15 tonnes/h of saturated steam at 400 kPa_g.

2.5.2.4.2 Process water

The facility will require raw water to be treated to boiler feed water, cooling water and potable water qualities. It is estimated that the site will require approximately 50 m^3/h of raw water. The source of water is yet to be finalised (refer also to Section 2.5.2.4.1). Potential sources of water supply that are being investigated include the Sedibeng Water Board and local gold mines.

2.5.2.4.3 Fuels

The fuels required for this project are summarised as follows:

- Diesel – will be supplied from tankers accessing the site via existing road infrastructure and stored on site in bulk storage containers. Up to 1 000 m^3 of diesel fuel will be stored on site as a backup fuel source for the power plant to ensure reliability of power output;
- Liquid Petroleum Gas (LPG) - LPG will be brought to site using existing road infrastructure and will be stored on site in bulk storage vessels; and
- Fuel gas (Syngas) - apart from electricity generation, syngas will be used primarily for utility steam generation.

2.5.2.4.4 Catalysts and Chemicals

Activated alumina (Al_2O_3 or Aluminium oxide) or titanium dioxide (TiO_2) catalyst is used in the sulphur removal unit (SRU) for the catalytic recovery of gaseous elemental sulphur via the Claus reaction. The catalyst will be replaced every two to four years during planned shutdown periods. Various chemicals will be required for use within the facility and the requirements will be confirmed during the detail design phase of the project.

2.5.2.5 Plant effluent

The plant will have a raw gas vent for start-up purposes and a flare to handle combustible gases to be vented during plant upsets and blow-off from relief valves.

Solid effluent will be minimal, consisting of ash generated by oxidizing the gas liquor, salts from the water treatment plant and sludge from the raw water clarifier. These wastes will be disposed of via registered waste treatment contractors.

Liquid effluents will be treated on site. Clean storm water will be diverted around process areas and routed to existing drainage lines and watercourses. All process areas will be bunded and runoff from such areas will be returned to the process water cleaning circuit and recycled.

2.5.2.6 Infrastructure requirements

A schematic site layout is shown in Figure 2-7. The infrastructure requirements for the project include the following:

- Electrical reticulation;
- Control and rack room;
- Safety systems;
- Laboratory and monitoring systems;
- Sewers and storm water systems;
- Pollution control dam;
- Brine pond;
- Workshop and warehouse facilities; and
- Site amenities and transportation infrastructure including security infrastructure.

All buildings will be provided with suitable concrete slabs and protected against corrosion where necessary. The existing farmhouse has a 400V electricity supply and will be used as administration offices.

Electricity supply and interconnection for the generated power will be discussed with Eskom to obtain a suitable solution and tie-in points. Possible routes have been identified in collaboration with Eskom and the preferred route shown on Figure 5-5 has been selected based on the lowest environmental and social impact.

Water Supply - The gasification process will require an estimated 9.5 m^3 of water per hour, while the power plant and ancillaries will require about 40 m^3/h. Potential alternative sources are discussed in section 5.6.

Africary has applied for a water use license.

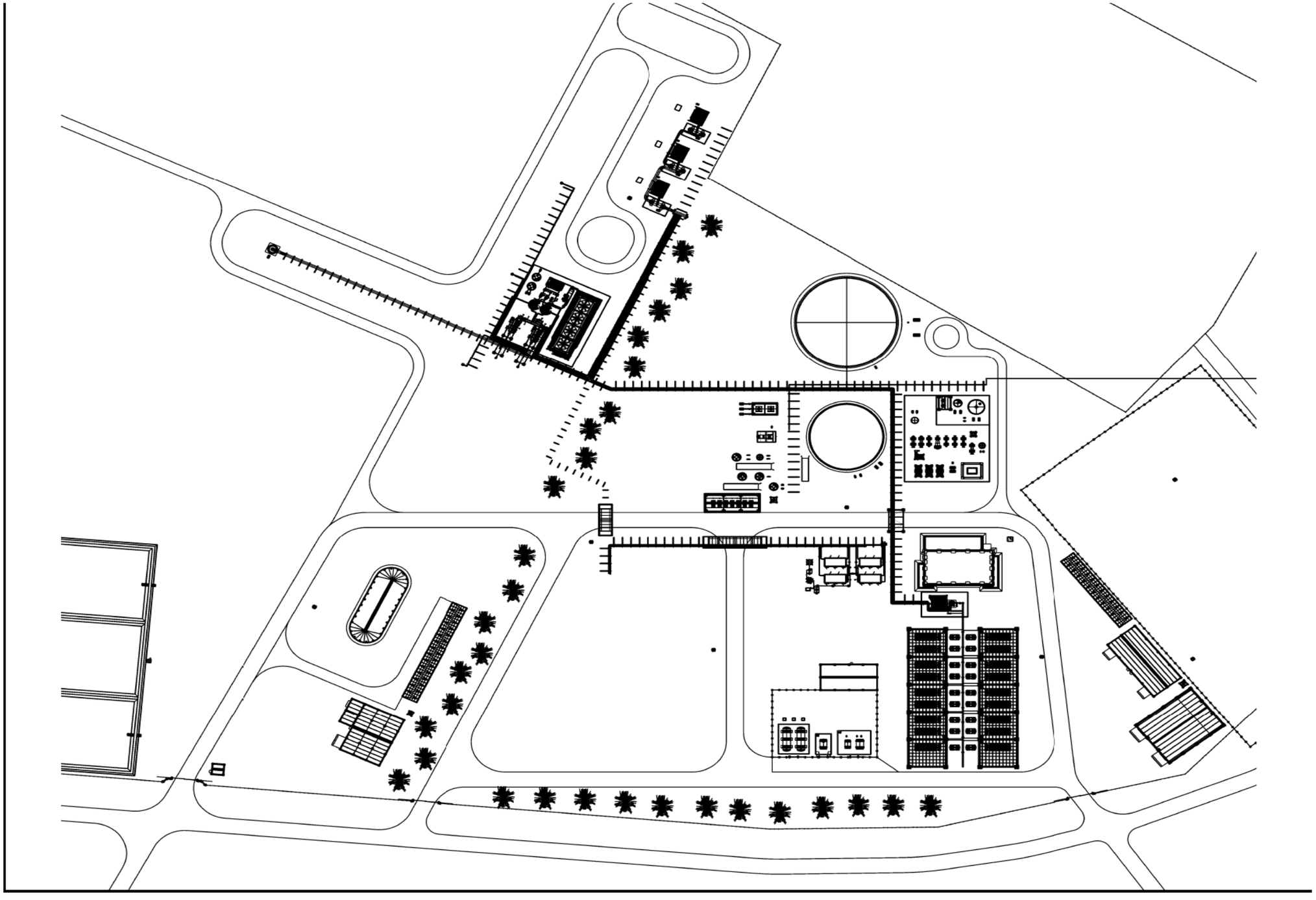


Figure 2-7: Schematic site layout

2.5.2.7 Safety, Security, Health and Environmental Issues

2.5.2.7.1 Safety

Process designs will consider process safety in terms of aspects that may result in human injury or death or in equipment damage. Potential risks will be identified, quantified and mitigated as far as possible through design adaptations. All statutory requirements, as referenced in section 3.1.6 regarding safety systems will be complied with.

The UCG process generates a combustible raw gas. Given unfavourable conditions, such a gas may present an explosive risk. Care will be taken in the design stages to minimise the potential for such conditions. Safety requirements and best practices for the handling of air enriched with oxygen will also be considered in the process design.

In addition to raw gas, a number of chemicals may be used or produced in the plant that may present potential safety hazards. The plant design process and operating procedures will provide for the safe handling of such substances. Material Safety Data Sheets (MSDS) for all such substances will be kept on site at all times.

Fire and gas alarms will be provided and automated process responses will be installed where necessary. Suitable fire-fighting systems will also be provided. The storage of flammable liquids will be handled in terms of the relevant SANS codes.

2.5.2.7.2 Security

Fencing will be provided around the complex in line with South African legal and safety guidelines. This includes fencing around the production facilities, workshops and control room. Access into the site will be monitored from both a security and a safety perspective.

2.5.2.7.3 Health

The specialist studies on air quality, noise, water management and waste management will identify potential human health risks in addition to environmental impacts and recommend appropriate mitigation measures. All potential impacts of the project on the health of workers, visitors and the general public will be minimised through implementation of suitable health management methods including, but not limited to, those listed below:

- Exposure to potential toxic substances will be minimised and controlled. This relates to solid, liquid and gaseous toxic substances. Emissions (vents, stacks and flares) will be directed in such a way that the impact is minimised.
- All potential toxic substances will be clearly labelled and identified;
- Pre-employment, transfer and exit medical examinations will be performed on all employees;
- Employees will be issued with the necessary personal protective equipment;
- A first-aid treatment facility will be available on site with trained personnel; and
- Noise abatement measures will be implemented where required to protect employees.

2.5.2.7.4 Environment

The core environmental objective is to minimise the adverse and enhance the positive impacts of the project on the biophysical and socio-economic environment in the vicinity of the project area.

Minimal quantities of effluent and solid waste will be generated and any effluents or wastes that cannot be treated on site, will be captured and transported in an appropriate manner to suitably licensed general and hazardous waste disposal facilities. An environmental specifications document will be developed during the design process. The design team will work closely with the independent environmental assessment consultants (see section 2.2) to ensure that environmental objectives are incorporated in the project design.

All water or liquids (gas liquor) produced by gasification will be destroyed on site by thermal destruction. Based on previous case studies, it is anticipated that only insignificantly small quantities of fly ash will be produced by the underground coal gasifier and that most of the ash produced will be retained inside the gasifier. Classification, labelling and packaging requirements for the transport of waste will comply with national legislation.

2.5.2.7.5 Mobility and Modularity

To support the moving of injection and production wells for the facility, certain operations need to be designed as mobile operations. Moving activities should take the shortest amount of time possible and therefore modular design is of utmost importance to minimise disassembly and assembly times. In this project, it is foreseen that the primary cooling process (quench column with its associated equipment) has to be easily moveable. It is necessary that the primary cooling step takes place as close as possible to the production well to avoid cooling and condensation of tarry substances in the pipeline transporting raw gas to the rest of the above ground processing facility. It is anticipated that this unit operation will be moved as production wells are moved. It is proposed that a second, identical unit be constructed when commissioning the second production well to allow for a hot change-over of production wells. In general, modular design will be exploited to minimise on site construction activities.

2.5.2.8 Design Life

The design life of the facility is expected to be 25 years with due consideration for specific equipment such as pumps, membranes and equipment associated with wells that will not be required for the full facility lifetime.

3.0 POLICY AND LEGISLATIVE CONTEXT

This section provides a brief overview of the policy and legal requirements that must be met by this project.

3.1 South African Legislation

3.1.1 National Environmental Management Act, 1998 (Act 107 of 1998)

There are a number of listed activities associated with the proposed UCG project that trigger the need to conduct scoping and impact assessment under the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA). The EIA will inform development of the Environmental Management Programme required under both the NEMA and the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA).

The current EIA regulations, GN R.982, GN R.983, GN R.984 and GN R.985, promulgated in terms of Sections 24(5), 24M and 44 of the NEMA and subsequent amendments, commenced on 4 December 2014. GN R.983 lists those activities for which a Basic Assessment is required, GN R.984 lists the activities requiring a full EIA (Scoping and Impact Assessment phases) and GN R.985 lists certain activities and competent authorities in specific identified geographical areas requiring a Basic Assessment. GN R.982 stipulates the EIA processes that must be undertaken to apply for environmental authorisation. The DEA is the regulating authority that considers applications for energy-related projects.

In terms of the NEMA and the EIA Regulations GN R.982 to GN R.985 of 4 December 2014, an application for environmental authorisation for certain listed activities to be undertaken as part of a mining operation must be submitted to the Department of Mineral Resources. The provincial environmental authority, in this case the Free State Province Department of Economic Development, Tourism and Environmental Affairs (DETEA), and the national authority (Department of Environmental Affairs, DEA) would participate in the EIA as commenting authorities.

The DMR recognised the fact that on 2 September 2015 the DEA had issued an integrated environmental authorisation (number 14/12/16/3/3/3/116) for all the listed activities originally applied for, and the DMR requested that Africary submit an application for environmental authorisation (AEA) for only the activities listed in Table 2-3. Such an AEA was submitted to the DMR on 2 December 2016. The AEA was accepted on 30 January 2017 and the reference number FS 30/5/1/2/3/2/1(10034) EM was issued.

The storage of about 18 m^3 of diesel fuel, 250 tons of liquid oxygen (LOX), and 100m^3 LPG and methane on site may require registration of the site as a Major Hazard Installation (MHI). A determination in this regard will be made prior to construction.

3.1.2 Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA)

In terms of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA) and the MPRDA Regulations R.527, an application for a mining right must be supported by an EIA process.

In terms of Regulation 3 of R.527, consultation must take place with interested and affected parties (I&APs), a scoping report conforming to Regulation 49(1) of R.527 must be submitted to the Department of Mineral Resources (DMR), followed by an environmental impact assessment report conforming to Regulation 50 and an environmental management programme (EMP) conforming to Regulation 51.

The EIA process being followed has been designed to be compliant with both the MPRDA Regulations and the EIA Regulations in terms of the National Environmental Management Act (NEMA), 1998 (Act 107 of 1998) as amended.

3.1.3 National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEMWA)

The National Environmental Management Waste Act (NEMWA) 2008 (Act 59 of 2008) requires that certain listed waste management activities must be licensed and that the licensing procedure must be integrated with an environmental assessment process. On 3 July 2009, GN 718 was published with definitions of the waste management activities that require licensing. A new list of licensable activities (GN 921) was published on 29 November 2013. These activities are divided into Category A (activities requiring a basic assessment), Category B (activities requiring scoping and EIA) and Category C activities dealing with the storage of waste, scrapping or recovery of motor vehicles and the extraction, recovery or flaring of landfill gas (requiring adherence to prescribed standards).

Africary will store brine (classified as hazardous waste) from a water treatment plant in lined evaporation ponds and may store up to 100 m^3 of hazardous products and general waste on site. a Waste Management Licence (WML) was issued by the DEA on 2 September 2015 as part of an integrated in environmental authorisation and in accoirdance with the requirements of the NEMWA. Regulations GN R.633 to GN R.636 of 23 August 2013 stipulate the requirements for waste storage and disposal. The scoping and EIA process described in sections 3.1.1 and 6.0 informed the WML application process.

3.1.4 National Water Act, 1998 (Act 36 of 1998)

The National Water Act, 1998 (Act 36 of 1998) (NWA) is the primary legislation regulating both the use of water and the pollution of water resources. It is applied and enforced by the Department of Water Affairs (DWA). Section 19 of the NWA regulates pollution, which is defined as "*the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it:*

- *Less fit for any beneficial purpose for which it may reasonably be expected to be used; or*
- *Harmful or potentially harmful to -*
    - *welfare, health or safety of human beings;*
    - *any aquatic or non-aquatic organisms;*
    - *the resource quality; or*
    - *the property."*

The persons held responsible for taking measures to prevent pollution from occurring, recurring or continuing include persons who own, control, occupy or use the land. This obligation or duty of care is initiated where there is any activity or process performed on the land (either presently or in the past) or any other situation

which could lead or has led to the pollution of water. The following measures are prescribed in section 19(2) of the NWA to prevent pollution:

- Cease, modify or control any act or process causing the pollution;
- Comply with any prescribed standard or management practice;
- Contain or prevent the movement of pollutants;
- Eliminate any source of the pollution;
- Remedy the effects of pollution; and
- Remedy the effects of any disturbance to the bed or banks of a watercourse.

Water use is defined in Section 21 of the NWA. Africary's proposed operations may involve the following water uses:

a) Taking water from a groundwater resource in terms of abstraction and use of borehole water for human consumption;

b) storing water;

g) disposing of waste in a manner which may detrimentally impact on a water resource;

h) disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;

Africary has engaged with the Department of Water and Sanitation and has applied for a water use licence.

Regulation 704 of 4 June 1999 defines the manner in which rainwater falling or flowing onto a mining area or an industrial site must be managed and requires *inter alia* the following:

a) Separation of clean (unpolluted) water from dirty water;

b) Collection and confinement of the water arising within any dirty area into a dirty water system;

c) Design, construction, maintenance and operation of the clean water and dirty water management systems so that it is not likely for either system to spill into the other more than once in 50 years;

d) Design, construction, maintenance and operation of any dam that forms part of a dirty water system to have a minimum freeboard of 0.8m above full supply level, unless otherwise specified in terms of Chapter 12 of the Act; and

e) Design, construction, and maintenance of all water systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with an average period of recurrence of once in 50 years.

3.1.5 National Environmental Management: Air Quality Act 2004, (Act 39 of 2004) (NEMAQA)

The gas fired power plant will be a local source of emissions. The proposed activity will require an Atmospheric Emission Licence (AEL) as it conforms to certain listed activities in the National Environmental Management: Air Quality Act 2004, (Act 39 of 2004) (NEMAQA). The listed activities that are likely to be applicable to the Africary project are discussed in section 11.1.2.1 of this report.

3.1.6 Occupational Health and Safety Act, 1993(Act 85 of 1993)

The OHSA and its various regulations are applicable to all industrial facilities and operations. Due to the proposed storage of large volumes of diesel fuel, LPG and liquid oxygen on site, the facility may have to be registered as a Major Hazard Installation in terms of the MHI Regulations, depending on the outcome of a risk assessment.

3.1.7 National Heritage Resources, 1999 (Act 25 of 1999) (NHRA)

A Phase I Heritage Impact Assessment (HIA) study, as required in terms of section 38 of the National Heritage Resources Act (NHRA) 1999, (Act 25 of 1999), will be undertaken on the farm Palmietkuil.

3.2 International

To provide for the eventuality that Africary will require funding from an institution that subscribes to the Equator Principles, Golder was instructed to incorporate the International Finance Corporation (IFC) Performance Standards (PS) on environmental and social sustainability, as well as the Equator Principles (EP) into the EIA.

The project parameters are such that it would, in terms of the IFC classification system, conform to a Category A project, which requires an Environmental, Social and Health Impact Assessment (ESHIA) for the Project comprising a scoping phase and an impact assessment phase. Two parallel impact assessment processes, with one report (i.e. the ESHIA) were undertaken for the project:

- South African regulatory process (EIA and EMPr) – which comprises of the following summarised steps:
  - Comprehensive public participation process running throughout the duration of the EIA process;
  - Scoping Report and Plan of Study for the EIA; and
  - EIA Report and EMPr.
- IFC process (ESHIA) – comprising of:
  - (i) Initial screening of the project and Project Definition;
  - (ii) Scoping of the assessment process and examination of alternatives;
  - (iii) Stakeholder identification (focusing on those directly affected) and gathering of environmental and social baseline data;
  - (iv) Impact identification, prediction, and analysis;
  - (v) Generation of mitigation or management measures and actions;
  - (vi) Significance of impacts and evaluation of residual impacts; and
  - (vii) Documentation of the assessment process (i.e. Project Definition, Scoping Report, Baseline Studies, Impact Assessment and Management Plans).

As the IFC ESHIA process is more extensive than the South African regulatory process, the information generated by the ESHIA was used to inform the South African regulatory process. The EIA documentation produced in this manner is suitable for submission to the South African authorities and, if required for funding purposes, submission to a financing institution that subscribes to the Equator Principles.

The ESHIA process is illustrated in Figure 3-1.

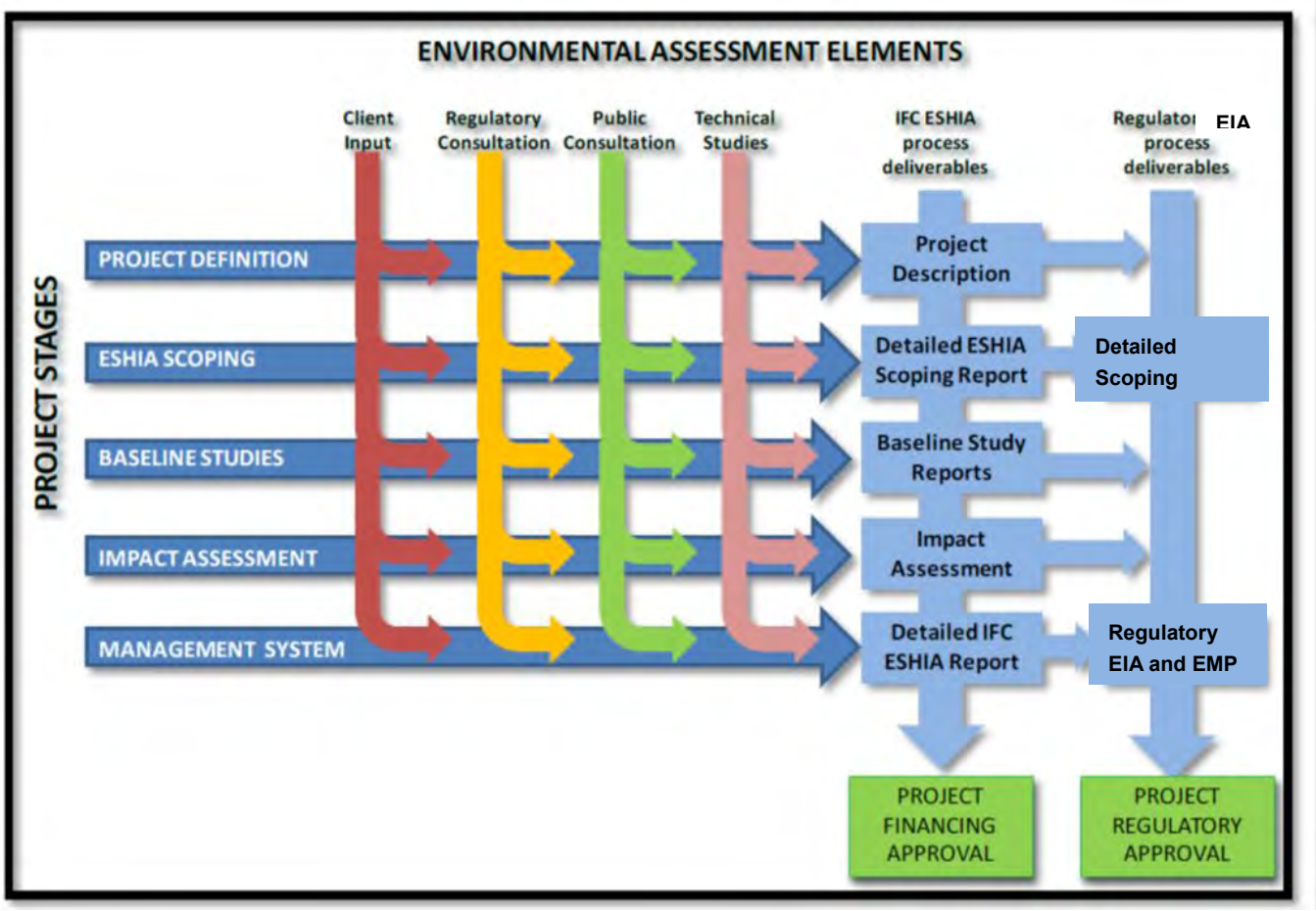


Figure 3-1: ESHIA process

3.2.1 International Conventions and Agreements

Relevant environmental and social international conventions and agreements to which South Africa is a party are presented in **Table 3-1** below.

Table 3-1: International conventions to which South Africa is a party

Convention	Summary of objectives or relevant conditions	South Africa Status
Antarctic Treaty (23 June 1961)	To ensure that Antarctica is used for peaceful purposes only (such as international cooperation in scientific research); to defer the question of territorial claims asserted by some nations and not recognized by others; to provide an international forum for management of the region; applies to land and ice shelves south of 60 degrees south latitude.	Party to.
Convention on Biological Diversity (29 December 1993)	Develop strategies, plans or programs for conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programs which shall reflect, inter alia, the measures set out in this Convention.	Party to.

Convention	Summary of objectives or relevant conditions	South Africa Status
Convention for the Conservation of Antarctic Seals (11 March 1978)	To promote and achieve the protection, scientific study, and rational use of Antarctic seals, and to maintain a satisfactory balance within the ecological system of Antarctica.	Party to.
Convention on Fishing and Conservation of Living Resources of the High Seas (20 March 1966)	To solve through international cooperation the problems involved in the conservation of living resources of the high seas, considering that because of the development of modern technology some of these resources are in danger of being overexploited.	Party to.
Convention on Wetlands of International Importance (Ramsar) (21 December 1975)	To stem the progressive encroachment and loss of wetlands now and in the future.	Party to.
Convention on the Conservation of Antarctic Marine Living Resources (7 April 1982)	To safeguard the environment and protect the integrity of the ecosystem of the seas surrounding Antarctica, and to conserve Antarctic marine living resources.	Party to.
Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES) (1 July 1975)	To protect certain endangered species from over-exploitation by means of a system of import/export permits.	Party to.
Convention on the Prevention of Marine Pollution (London Convention) (30 August 1975) in force 1996	To control pollution of the sea by dumping and to encourage regional agreements supplementary to the convention.	Party to.
International Convention for the Regulation of Whaling (10 November 1948)	To protect all species of whales from overhunting; to establish a system of international regulation for the whale fisheries to ensure proper conservation and development of whale stocks; and to safeguard for future generations the great natural resources represented by whale stocks.	Party to.
United Nations Framework Convention on Climate Change - Kyoto Protocol (23 February 2005)	To further reduce greenhouse gas emissions by enhancing the national programs of developed countries aimed at this goal and by establishing percentage reduction targets for the developed countries and through the clean development mechanism (CDM) (where developed countries can invest in developing country clean technology to offset emissions).	Party to.
Montreal Protocol on Substances That Deplete the Ozone Layer (1 January 1989)	Calculated levels of consumption and production of CFCs must not exceed the stipulated thresholds.	Party to.
Protocol of 1978 Relating to the International Convention for the Prevention of Pollution From Ships, 1973 (MARPOL) (2 October 1983)	To preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances.	Party to.

Convention	Summary of objectives or relevant conditions	South Africa Status
Protocol on Environmental Protection of the Antarctic Treaty (14 January 1998)	To provide for comprehensive protection of the Antarctic environment and dependent and associated ecosystems; applies to the area covered by the Antarctic Treaty.	Consultative party.
Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water (10 October 1963)	To obtain an agreement on general and complete disarmament under strict international control in accordance with the objectives of the United Nations; to put an end to the armaments race and eliminate incentives for the production and testing of all kinds of weapons, including nuclear weapons.	Party to.
United Nations Convention on the Law of the Sea (LOS) (16 November 1994)	To set up a comprehensive new legal regime for the sea and oceans; to include rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment.	Party to.
United Nations Convention to Combat Desertification (26 December 1996)	To combat desertification and mitigate the effects of drought through national action programs.	Party to.
United Nations Framework Convention on Climate Change (21 March 1994)	Protection of the climate system: Operations must protect the climate system by controlling greenhouse gases not controlled by the Montreal Protocol, which cause climate change through anthropogenic interference with the climate system.	Party to.
* Sources: United States Central Intelligence Agency World Fact book (www.cia.gov/library/publications/the-world-factbook/index.html)		
Stockholm Convention on Persistent Organic Pollutants (POPs) (17 May 2004)	This convention seeks to ban the production and use of persistent organic chemicals but allow the use of some of these banned substances, such as DDT, for vector control.	Party to.
The Fourth ACP-EEC Convention 15 December 1989 (Lomé)	Control of hazardous and radioactive waste: the operation must be aware that international law emphasises strict control of hazardous waste and compliance with domestic legislation in this regard. It also seeks to prohibit imports and exports of such substances.	Party to.
Convention concerning the Protection of the World Cultural and Natural Heritage 1972 (Paris)	Ensuring the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage	Ratification.
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (24 February 2004)	Promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm	Party to.

3.2.2 International Finance Corporation Performance Standards

African Carbon Energy (Pty) Ltd is committed to complying with the International Finance Corporation (IFC) performance standards (PS) on social and environmental sustainability. These were developed by the IFC and were last updated on 1st January 2012. The overall objectives of the IFC PS are:

- To fight poverty;
- To do no harm to people or the environment;
- To fight climate change by promoting low carbon development;
- To respect human rights;
- To promote gender equity;
- To provide information prior to project development, free of charge and free of external manipulation;
- To collaborate with the project developer to achieve the PS;
- To provide advisory services; and
- To notify relevant countries of any trans-boundary impacts as a result of a project.

The PS comprise of eight performance standards namely:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labour and Working Conditions;
- Performance Standard 3: Resource Efficiency and Pollution Prevention;
- Performance Standard 4: Community Health, Safety and Security;
- Performance Standard 5: Land Acquisition and Involuntary Resettlement;
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- Performance Standard 7: Indigenous Peoples; and
- Performance Standard 8: Cultural Heritage.

The PS framework is presented in Figure 3-2. Performance Standard 1 establishes the importance of:

(i) integrated assessment to identify the social and environmental impacts, risks, and opportunities of projects;
(ii) effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and
(iii) the management of social and environmental performance throughout the life of a project through an effective Environmental and Social Management System (ESMS).

PS 1 is the overarching standard to which all the other standards relate. The ESMS should be designed to incorporate the aspects of PS 2 to 8 as applicable.

Performance Standards 2 through 8 establish specific requirements to avoid, reduce, mitigate or compensate for impacts on people and the environment, and to improve conditions where appropriate. While all relevant social and environmental risks and potential impacts should be considered as part of the assessment, Performance Standards 2 through 8 describe potential social and environmental impacts that require particular attention in emerging markets. Where social or environmental impacts are anticipated, the

developer is required to manage them through its Social and Environmental Management System consistent with Performance Standard 1.

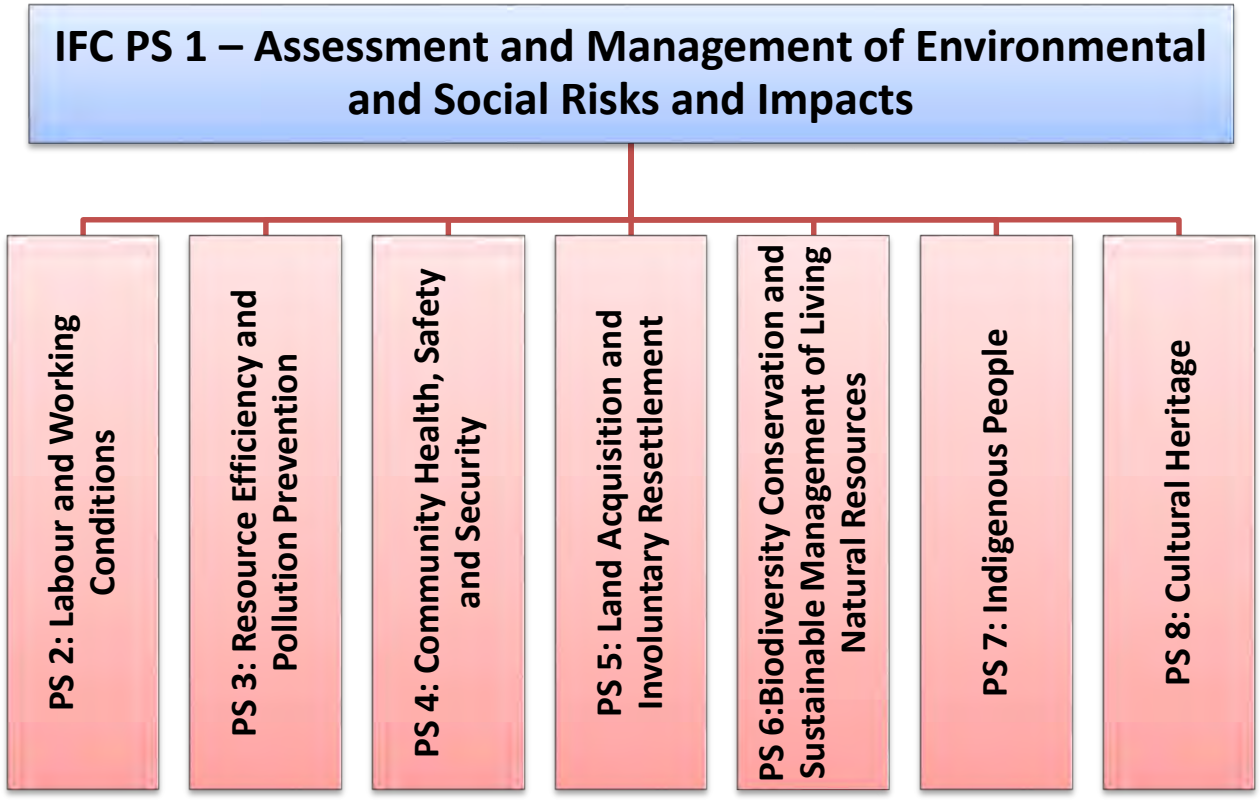


Figure 3-2: The IFC PS Framework

3.2.3 Equator Principles

The Equator Principles (EPs) constitute a credit risk management framework for determining, assessing and managing environmental and social risk in Project Finance transactions. Project Finance is often used to fund the development and construction of major infrastructure and industrial projects.

The EPs are adopted by financial institutions and are applied where total project capital costs exceed US$ 10 million. The EPs are primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making.

The EPs are based on the International Finance Corporation Performance Standards on social and environmental sustainability and on the World Bank Group Environmental, Health, and Safety Guidelines (EHS Guidelines).

The Equator Principles Financial Institutions (EPFIs) have consequently adopted these Principles in order to ensure that the projects they finance are developed in a manner that is socially responsible and reflect sound environmental management practices.

EPFIs will only provide loans to projects that conform to the following principles:

- Principle 1: Review and Categorisation;
- Principle 2: Social and Environmental Assessment;

- Principle 3: Applicable Social and Environmental Standards;
- Principle 4: Action plan and Management;
- Principle 5: Consultation and Disclosure;
- Principle 6: Grievance Mechanism;
- Principle 7: Independent review;
- Principle 8: Covenants;
- Principle 9: Independent Monitoring and Reporting; and
- Principle 10: EPFI Reporting.

3.2.4 The World Bank Group Environmental Health and Safety (EHS) Guidelines

The EHS Guidelines (World Bank Group, 2007) are technical reference documents with general and industry specific (i.e. mining) examples of Good International Industry Practice (GIIP). Reference to the EHS guidelines is required under IFC PS 3.

The EHS Guidelines contain the performance levels and measures normally acceptable to the IFC and are generally considered to be achievable in new facilities at reasonable cost. When host country regulations differ from the levels and measures presented in the EHS Guidelines, Projects are expected to achieve whichever standard is more stringent.

3.2.5 Environmental and Social Management System and Action Plans to be developed

IFC Performance Standard 1 establishes the importance of: (i) integrated assessment to identify the social and environmental impacts, risks, and opportunities of Projects; (ii) effective community engagement through disclosure of Project-related information and consultation with local communities on matters that directly affect them; and (iii) the management of social and environmental performance throughout the life of the Project through an effective Environmental and Social Management System (ESMS). PS 1 is the overarching standard to which all the other standards relate. The proposed ESMS is designed to incorporate the aspects of PS 2 to 8 as applicable (Figure 3-2).

The following standard components of an ESMS and corresponding Environmental and Social Management Plan (ESMP) report will be addressed to the extent that they are applicable to this project:

Step 1 – Development of Stakeholder Engagement and Monitoring Modules

- Development of the framework Stakeholder Engagement and Grievance Mechanism Module;
- Development of the framework module for recording environmental and social monitoring data; and
- Development of the ArcGIS server platform, monitoring dashboards and reporting.

Step 2 – Development of the ESMP

The ESMP will be developed following completion of the Impact Assessment and will be structured to include (i) policy; (ii) identification of risks and impacts; (iii) management programs; (iv) organizational capacity and competency; (v) emergency preparedness and response; (vi) stakeholder engagement; and (vii) monitoring and review. The ESMP will be structured as a stand-alone document that will then be converted into an Environmental and Social Management System (ESMS). The management/action plans will be developed based upon the framework below:

- Identification and rating of impacts through the impact assessment process;
- Development of specific mitigation measures based on the mitigation hierarchy (avoidance, reduction, rehabilitation and compensation/offsetting) to manage those impacts;

- Determine suitable timeframes, responsibilities, methods, performance indicators and targets, and costs for selected mitigation/management measures (in consultation with proponent/Project design team); and
- Consolidate selected measures, timeframes, responsibilities and performance indicators into comprehensive action plans.

The ESMP will include the following additional plans which will be generated by the specialist studies:

- Groundwater Management Plan;
- Rehabilitation and Closure Plan;
- Risk and Emergency Control Plan;
- Stakeholder Engagement Plan;
- Influx Management Plan;
- Community Development Plan (see below for further detail);
- Community Health and Safety Plan (see below for further detail); and
- Recruitment and Training Plan.

Step 3 – Conversion of the ESMP to the ESMS

Based on the framework laid out by the ESMP, the ESMS will be developed on an Isometrix™ platform. The ESMS will be customised to Africary's organisational structure, and will include all the measures and specific management plans outlined in the ESMP, with responsibilities assigned. The ESMS will also allow for new or unforeseen impacts to be rated and new mitigation measures to be assigned once the ESMS goes live. Mitigation measures will also go through a process of continual review, with the database updated and changes tracked.

At the end of the process Africary will have a customised live, easily auditable ESMS that will track management actions, stakeholder issues and monitoring actions, and will be easily updated. Regular reporting will be automated by the system in the format as required by the client, regulator or financier.

3.2.6 Health, Safety and Security

Africary will develop and implement appropriate policies and emergency response plans to address the health, safety and security of Africary's personnel and any communities that may be in close proximity to the mining operations.

3.2.7 Safety, Health, Environment and Community Policy

Africary's SHEC Policy will be conveyed to each new personnel member during induction and training upon appointment. It will also be prominently displayed in all work areas.

The application of the policy will set out in the Company's SHEC Management System Manual, which will be developed prior to the commencement of construction.

3.2.8 Emergency Response Plans

Africary will also develop and implement an appropriate emergency response plan to deal with general emergency situations such as fire, injuries, bomb threats, leakage of radionuclides from nuclear instruments etc. (Mandatory Code of Practice on Emergency Preparedness and Response - Ref Number: MCOP-VP-03. Revision No: 1, 2012). There will also be procedures for dealing with hydrocarbons and other wastes, including a spillage response procedure.

3.3 Administrative Framework

The project being permitted includes:

- UCG gasification area, , 150 ha, 30-40 ton/h for 20 years
- Gas cleaning and power generation, combined footprint of 3 - 5 ha;
- Distribution line (132 kV), and
- Raw water pipeline in the new Eskom power line servitude.

3.3.1 Department of Mineral Resources (DMR)

The Department of Mineral Resources (DMR) through its Mineral Regulation Branch (MRB) is responsible for regulating the mining and minerals industry to achieve transformation and contribute to sustainable development. The purpose of the MRB is to administer the MPRDA and other applicable legislation. Its objectives are to ensure the granting of prospecting and mining rights in terms of the Act and to promote mineral development, urban renewal, rural development and black economic empowerment. It is responsible for co-ordinating and liaising with national, provincial and local government structures for efficient governance. It is also tasked with addressing past legacies with regard to derelict and ownerless mines and enforcing legislation regarding mine rehabilitation.

Upon commencement of the EIA Regulations GN R.982, R.983, R.984 and R.985 on 4 December 2014, the DMR became responsible for the granting of mining rights, environmental authorisations and waste management licences for mining-related projects. The national and provincial environmental departments remain involved in such projects as commenting authorities.

3.3.2 Department of Economic Development, Tourism and Environmental Affairs Free State Province (DETEA)

In South Africa, EIA is the responsibility of both national and provincial government institutions. Policy formulation and coordination takes place at national level, while approval of EIAs for most development proposals has been delegated to the provinces. In terms of the EIA Regulations of 2014, the provinces are defined as competent authorities for environmental authorisation for most of the listed activities, *i.e.* they are empowered to authorise development activities.

3.3.3 Department of Environmental Affairs (DEA)

The DEA is the competent authority for the authorization of energy-related projects and the granting of waste managemenent licences for activities involving hazardous waste.

The issuing of atmospheric emission licenses (AELs) has been delegated to certain local authorities and an application for an AEL in terms of the NEMAQA was submitted to the Lejweleputswa District Municipality, who issued a provisional AEL with the number LDM/AEL/LCR/005 on 16 November 2015.

3.3.4 Department of Water Affairs

The Department of Water Affairs (DWA) is the custodian of South Africa's water resources. It is primarily responsible for the formulation and implementation of policy governing the water sector. It also has overall responsibility for water services provided by local government. The NWA provides the DWA with the authority and the tools for the optimal management of South Africa’s water resources. The registration and licensing of water use is one of these tools and is a statutory obligation for this project. The WUL application will be submitted to the DWA in terms of the requirements of the NWA.

4.0 PROJECT MOTIVATION: NEED AND DESIRABILITY OF PROPOSED ACTIVITIES

An adequate and reliable electricity supply at affordable cost to meet growing demand in South Africa is essential for economic growth. The private sector can play an important role in addressing the future electricity needs of South Africa through projects such as distributed generation, co-generation and renewable energy projects.

The introduction of private sector generation will contribute to the diversification of both the supply and nature of energy production, inject new skills and capital into the industry, and enable the benchmarking of performance and pricing.

When compared to traditional coal mining and power generation, UCG eliminates mine safety issues, surface damage and solid waste discharge, and reduces sulphur dioxide (SO_2) and nitrogen oxide (NOx) emissions (Kochetkov & Lazarenko, 1997) (Shu-qin & Jun-hua, 2002). The ash content of UCG gas burnt in a gas turbine is approximately 0.05 mg/m³ compared to smoke from traditional coal burning, where the ash content may be up to 70 mg/m³ (Walter, 2007). Control is exercised mainly by the rate at which oxygen is introduced into the coal seam. (Burton , Friedmann, & Upadhye, 2007)

One of the most obvious advantages of UCG versus conventional, above ground coal gasification is that it allows for economic exploitation of coal seams that would otherwise not be mineable economically or even at all. For conventional gasification, the coal needs to be mined either by sinking shafts underground and transporting the mined coal to the surface, or by open cast mining of shallow deposits. Both these activities are expensive in terms of capital cost and in terms of environmental and health implications. With conventional mining activities coal seams that are too deep or too thin cannot be mined economically because of the high costs involved in mining activities.

Conventional coal mining also results in stockpiles of mining waste and discard coal and often leads to acid mine drainage. Conventional gasification in a surface plant or direct burning of coal to produce heat and power results in stockpiles of ash and this may also lead to acid drainage.

UCG provides a means to exploit coal seams located deep underground with no humans having to work underground, with a minimal aboveground footprint, with lower atmospheric emissions, no waste or discard coal stockpiles, no ash stockpiles above ground, much lower risk of acid mine drainage and it leaves coal's most toxic elements – mercury, arsenic, and lead – largely underground (Kelly-Detwiler, 2012).

Subsidence and groundwater management are common issues with all forms of extractive mining. The size of any void left after UCG is typically smaller than that created by other methods of coal extraction because all the un-burnt coal and the ash remain behind, filling the void, and it typically experiences a goaf and becomes filled with rubble that falls from the roof and is recompressed over time. The degree and extent of subsidence caused by UCG, if any, depends on the thickness and spatial extent of the coal seam, its depth below surface and the characteristics of the layers of rock above it.

The coal seam at the target area lies more than 340 metres deep and it is 3.2 metres thick. Based on the rock mechanical properties determined from drill cores, subsidence of about 1.0 to 1.2 m may be expected within the UCG target area, which is unlikely to be significant within the context of current and future land use.

5.0 PROJECT ALTERNATIVES AND PROCESS FOLLOWED TO REACH PREFERRED ALTERNATIVE

Alternatives are different means of meeting the general purpose and need of a proposed activity. Alternatives help identify the most appropriate method of developing the project, taking into account location or site alternatives, activity alternatives, processes or technology alternatives, temporal alternatives and the no-go alternative. Evaluation of alternatives also allows the relative impact of different project alternatives on the environment to be considered. The target area to be exploited initially is indicated in red in Figure 5-1.

5.1 Alternative Power Plant Sites

After considering several potential sites for the establishment of the power plant and its associated infrastructure, the choice was narrowed down to the two sites indicated on Figure 5-1, which were then subjected to further evaluation of their suitability for establishing the infrastructure footprint associated with the aboveground facilities. The preferred site for establishing the infrastructure is the area to the west of the access road (outlined in black), which is in close proximity to the current farm house with infrastructure already available (400V power, French drain and potable water from a borehole that is used for domestic purposes). The alternative infrastructure footprint (yellow dotted outline) is located close by on the eastern side of the access road.

The following factors were considered in arriving at the preferred choice of infrastructure site:

- The preferred infrastructure site is underlain by a dolerite dyke, which will contribute towards good founding conditions;
- The farmhouse at the preferred site can be used as an office block. It has power, water and sewage connections that can be used for construction purposes. Such infrastructure would have to be built at the alternative site across the road;
- Small geophytes growing on the alternative site would have to be relocated;
- The preferred site has an existing access road; and
- The existing eucalyptus around the preferred site will provide shade, a wind break and a degree of visual screening.

5.2 Alternative UCG Target Areas

Two UCG target areas have been considered by Africary as illustrated in Figure 5-1. There is little to choose between the two UCG target sites. The process will takes place more than 340 metres underground, with no effects at the surface. The preferred target area is located on the western side of the road adjacent to the Palmietkuil stream (solid green outline). It lies below grazing land and is adjacent to the preferred power plant site. The second alternative considered (dotted green outline) is further away from the preferred power plant site and is separated from it by a road, which would require pipelines to cross the road between the infrastructure site and the UCG target area. It is also located mostly below grazing land and agricultural fields.

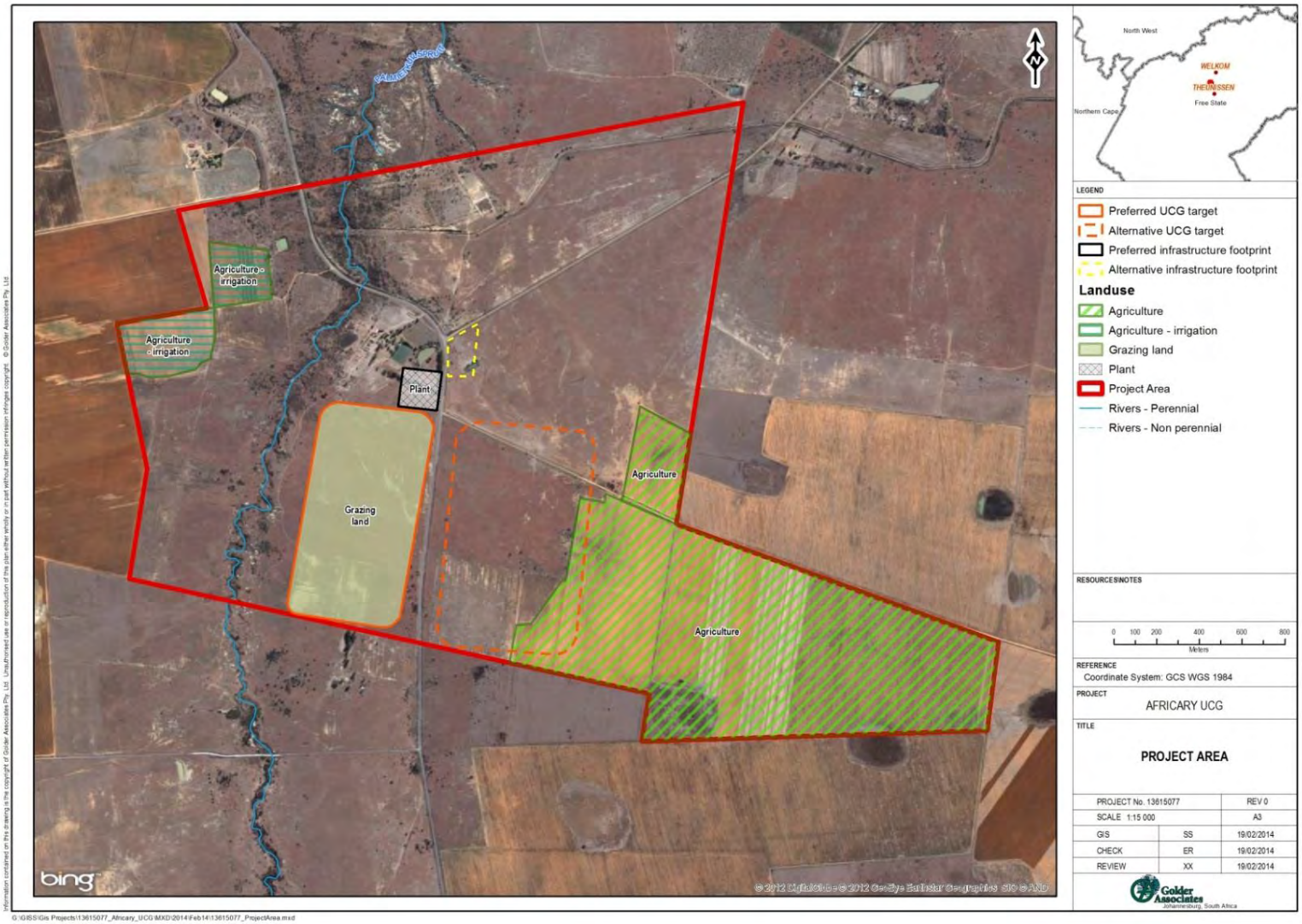


Figure 5-1: Alternative UCG target areas and infrastructure footprints

5.3 Alternative Means of Power Generation

Africary and its engineering consultants (CDE Process (Pty) Ltd) have considered gas turbines and reciprocal gas engines as primary drivers for the electrical power generators.

A gas turbine capable of driving a 60 MW power plant is relatively small, about the size of a jet engine on a modern large passenger aircraft. It could fit inside a container, and the ancillary infrastructure, consisting of water and power reticulation, a security kiosk, offices and a workshop, would occupy more space than the gas turbine itself. See Figure 5-2 for an illustration of a typical gas turbine for power generation in the 60 MW range.

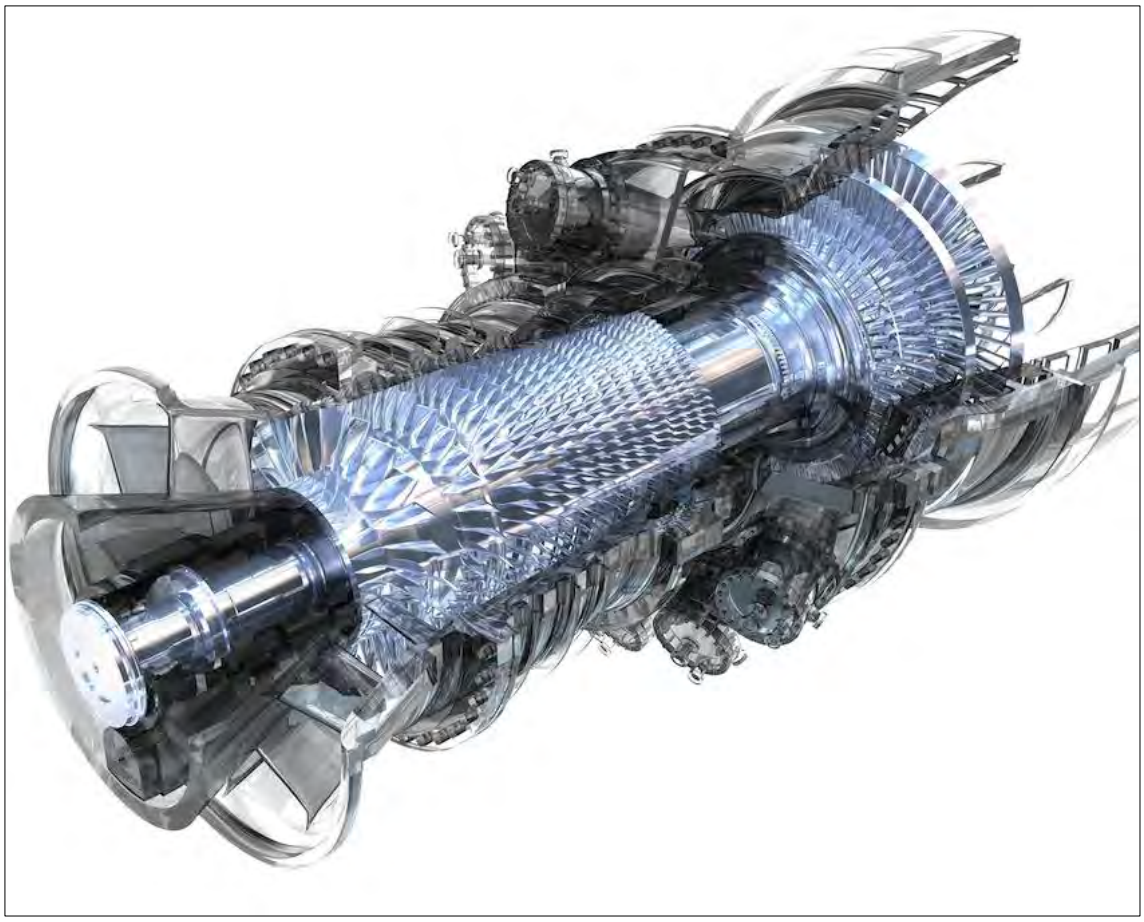


Figure 5-2: GE Flex efficiency 60 NG Turbine

The reciprocal gas engine was the predecessor of the present day diesel and petrol engines. Today gas engine generators are available in ranges from 250 kW to 18 MW, with computerised control for high efficiency. They can use natural gas, gas from biomass sources, landfill gases, mine gases and other inorganic gases from various industrial processes (e.g. by-product CO from metal smelters, or H_2 from several industrial chemical processes that produce chlorine, sodium chlorate, ethylene and styrene).

Reciprocating engines are ideally suited to modular use, e.g. a modular power plant based on 20 reciprocating engines, each with 4 MW capacity, can deliver a range of output from less than 4 MW to 80 MW. Because the start-up time for reciprocating engines is only a few minutes, the power plant can respond to changes in load demand rapidly by bringing additional engines sets online.

When a gas turbine is required to operate well below its design load, the compressor airflow may not be enough to support conversion of carbon monoxide (CO) into carbon dioxide (CO_2) in the combustion chamber, in which case the turbine would lose efficiency and fail to meet emission standards. Gas turbines are generally constrained to a turndown of 30 to 40 per cent of full load to meet emissions regulations.

A modular power plant based on multiple reciprocating engines does not have similar restrictions on load turndown as individual engines may be switched off when not required.

5.4 Air Enrichment

The project may require up to 350 tons of oxygen per day. The following air enrichment options were considered:

Table 5-1: Air enrichment alternatives

Air Enrichment Options considered	Advantages	Disadvantages
Cryogenic air separation	Widely used technology for large-scale facilities	High capital and operating costs
Membrane air separation	Economic on smaller-scale facilities where lower oxygen quality is required	Large compressor is required for compression of air
Pressure swing adsorption (PSA)	Suited for small-scale oxygen production	Not adequate to produce the required amounts of oxygen for this project and therefore discarded
Vacuum swing adsorption (VSA)	Better suited than PSA for production of more than 20 tons of oxygen per day	Capital cost
Liquid oxygen (LOX)	No capital cost. Close proximity to LOX producers	Must be trucked to site and would have a high commodity and transport cost

Using compressed air only will be weighed up as the primary option against installing a VSA unit during further process development.

The utilization of Gas Engines simplifies the gas processing facility and requires only gas cooling.

5.5 Syngas Desulphurisation

If a combined cycle gas turbines are used, the fuel gas may need to undergo a sulphur removal process. The four sulphur removal technologies summarised below were considered.

Table 5-2: Syngas desulphurisation alternatives

Syngas Processing	Advantages	Disadvantages
CrystaSulf®	Acid gas removal and sulphur recovery occurs in one process	CrystaSulf® technology has a relatively low commercialization level
SulfaTreat® direct oxidation	Syngas process is simplified significantly	Has not been tested commercially
SELEXOL®	SELEXOL® technology is widely used in industry and has been very well proven.	High level of commercialization
A Fluidized Bed Incinerator	Considered for due diligence purposes	High costs associated with waste treatment and stockpiling

Desulphurisation is not necessary if gas engines are used.

5.6 Water Supply

The farm has an agricultural permit for irrigation usage with a yield of approximately 10m^3/h. This water is allocated on a seasonal basis, based on water availability and is therefore not a reliable source during dry periods where water restrictions can be applied.

Several options for supply of the water required for industrial use from various sources were considered. There are small rivers nearby from which water could possibly be sourced, including the Palmietkuil spruit and Sand River. Further investigation will be undertaken to determine whether these rivers have sufficient quantities of water and whether abstraction would be allowed by the Department of Water Affairs. Water could also be sourced from one or more of the gold mines in the vicinity or from the Sedibeng Water system via a new pipeline along the route of the new 132kV Power Line.

Discussions with the SandVet Water Users Association (WUA) have indicated that the WUA might also be able to supply the project's needs. This is the preferred water source for the project project as the WUA already supplies 1,800 m^3 a week to the farm *via* an existing irrigation canal.

5.7 Wastewater Treatment

Different waste water processing options were considered during the technology selection process. See Figure 5-3. Possible contaminants include organic and inorganic / metal-based components.

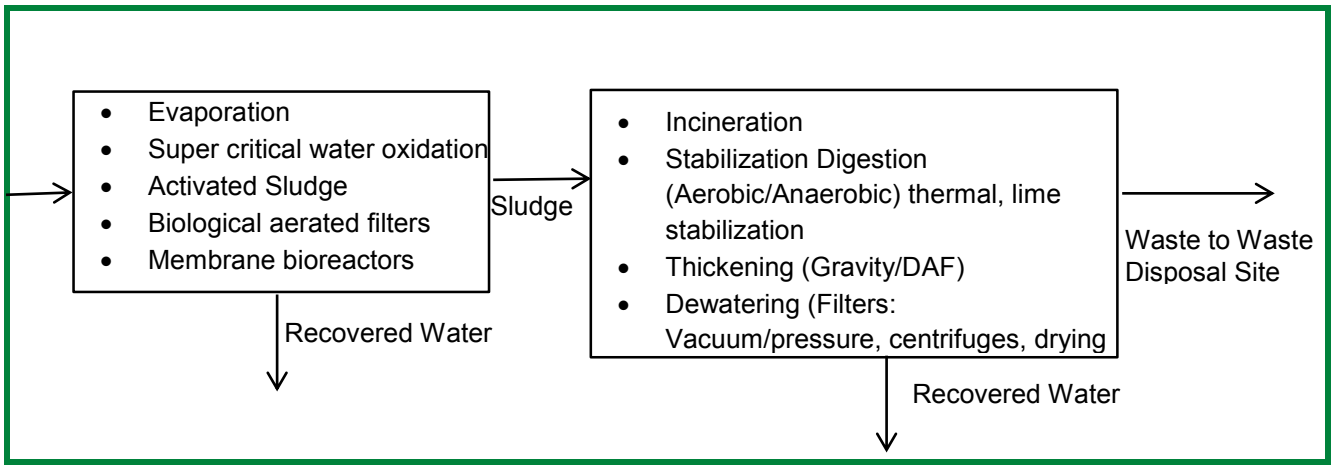


Figure 5-3: Wastewater treatment options considered

Of the options considered, biological waste treatment processes were disqualified because of their limitations in treating aromatic components such as benzene. This left two primary options:

- Fluidized bed incineration; and
- Super critical water oxidation (improvement over wet oxidation).

Fluidized bed incineration is associated with high capital, operating and maintenance costs (complex equipment), as well as large amounts of solid waste that must be disposed of. Super critical water oxidation (SCWO), which is illustrated in Figure 5-4 is characterised by a simple process.

The SCWO reaction takes place at elevated temperatures and pressures above the critical point of water (Pc= 220.55 bar, Tc=373.976 ^oC). SCWO is ideally suited for treating waste streams containing high concentrations of water. SCWO processing systems are fully enclosed and do not produce hazardous air pollutants (HAPS) or NOx. SCWO is energy neutral and it does not require lime/sand or the removal of large amounts of solid waste. It provides an effective means of destroying hazardous waste, with minimal environmental impact; relatively low capital cost and reduced operational costs. Supercritical oxidation selection eliminates the need for sludge disposal. The focus will therefore be placed on implementing super critical oxidation to destroy waste, primarily originating from the gas liquor portion of the syngas.

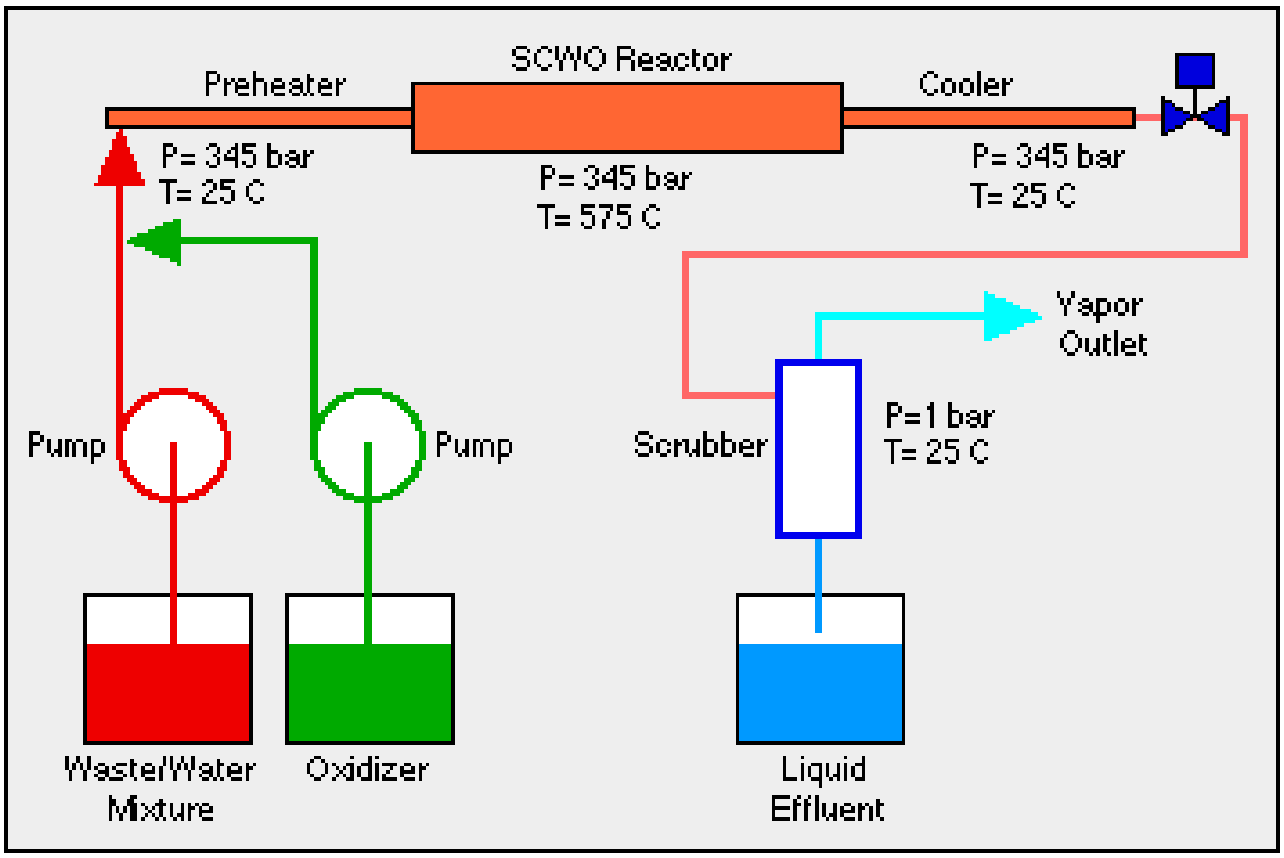


Figure 5-4: Schematic flow sheet for super critical water oxidation

5.8 Alternative routes for power line and water pipeline

The alternative route alignments for the power line and the potential water pipeline that have been identified for further study and evaluation are shown in Figure 5-5.

Routes 1, 2 and 3 and 4 are approximately 16.7km, 14.6km 13.3km and 8.9 km respectively in length. Route 1 is the preferred route, but also the most expensive. It follows a path close to existing road infrastructure and does not cross directly over farmlands. Route 2 is shorter, but not favoured because of very wet soil conditions adjacent to Beatrix Mines tailings and evaporation dams. Route 3 avoids these concerns but takes a direct route across farms to the UCG Plant, also providing a significantly shorter route. This route initially follows the service roads of the mines and then crosses the stream at the road crossing. Route 4 is the shortest and lowest cost, but also passes across farmlands and close to the Beatrix mine tailings dams.

5.9 Post-closure land use

Currently the land is used primarily for grazing. Surface subsidence of 1.0 to 2.0 metres may be expected directly above the UCG areas, but the land above the UCG areas will remain fit for grazing and crop cultivation.

Post-closure land use options of the infrastructure site will be explored in the closure plan which will be developed as part of this EIA / EMPr process. The options will seek to provide a sustainable land use and, unless some other preferred end use is identified for the infrastructure footprint the area will be rehabilitated to a condition fit for agricultural use.

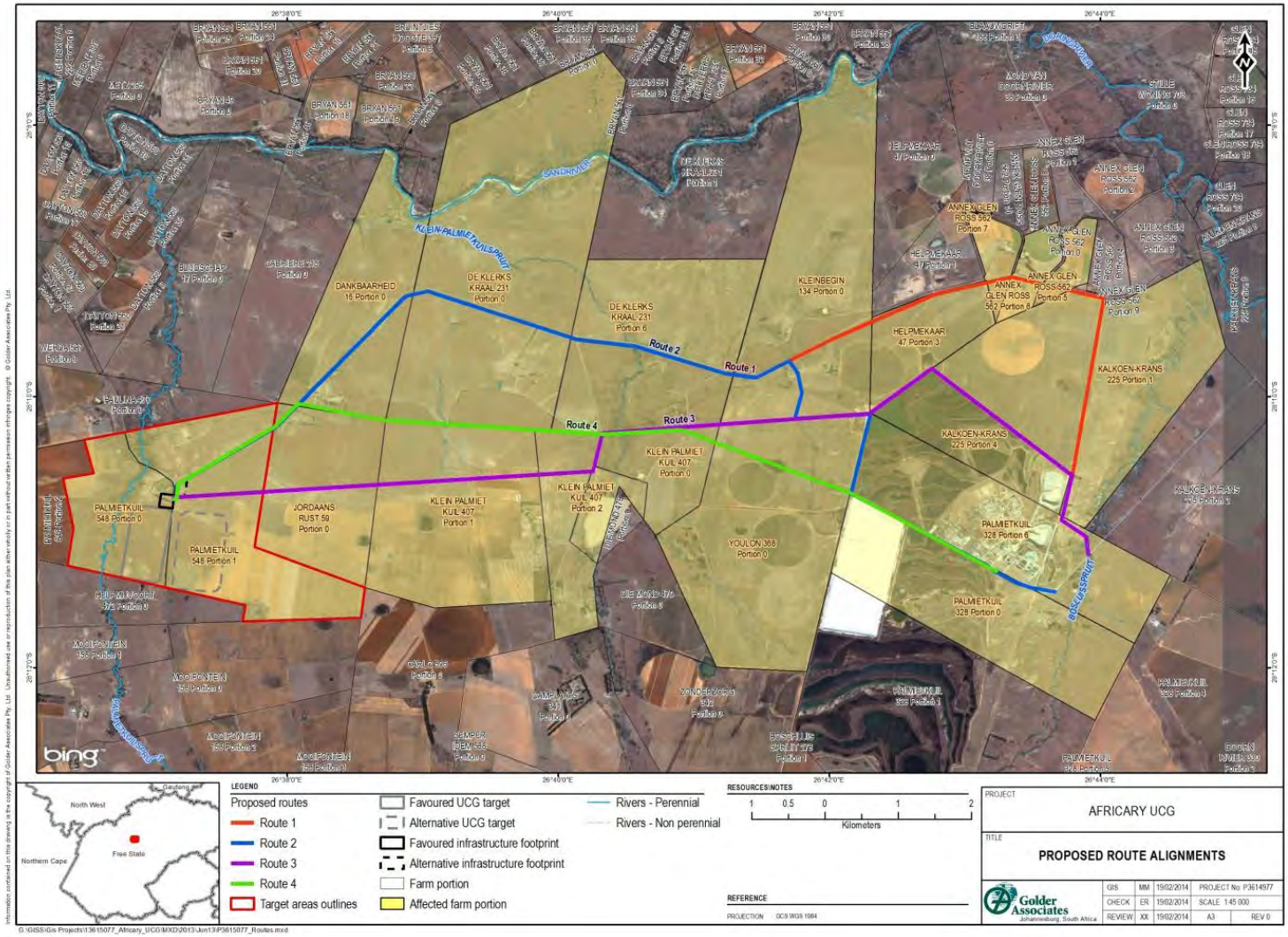


Figure 5-5: Alternative power line and water pipeline routes varying in length from 11 to 16.7 km

5.10 No-Project Option

Under current and projected market conditions the identified coal resources cannot be recovered using traditional opencast or underground mining methods, but UCG offers a viable method of utilizing these resources for power generation, with much lower environmental impacts than conventional coal mining and coal fired boilers. Africary views the proposed project as a flagship project that would serve as a springboard for other, more extensive UCG projects.

The no-project option will result in the continuation of current land use, namely grazing and maize production. The agricultural value of the land within the proposed UCG area is low with mainly grazing activities and 6 ha of irrigated land. Of the 600 ha available only 150 ha has a long-term dry land maize production record and this is not currently targeted for UCG operations. The project would sterilize about 3 ha of land for about 20 years, after which it would be restored to a state fit for grazing. The crop production potential would not be affected.

If the project is not implemented, Africary would not have a demonstration project from which to develop other UCG projects and the coal seams would remain where they are, but other companies may well propose similar projects in the future.

6.0 PUBLIC PARTICIPATION

This section provides an overview of the public participation process undertaken during the EIA.

6.1 Objectives of public participation

Opportunities for Comment

Documents were made available at various stages during the EIA/EMPr process to provide stakeholders with information, further opportunities to identify issues of concern and suggestions for enhanced benefits and to verify that the issues raised have been considered.

The principles that determine communication with society at large are included in the principles of the NEMA, as amended and are elaborated upon in General Notice 657, titled *"Guideline 4: Public Participation"* (Department of Environmental Affairs and Tourism, 19 May, 2006), which states that: *"Public participation process means a process in which potential interested and affected parties (I&APs) are given an opportunity to comment on, or raise issues relevant to, specific matters".* Public participation is an essential and regulatory requirement for an environmental authorisation process, and must be undertaken in terms of Regulations 54 to 57 of the EIA Regulations GN R.543 (June 2010). Public participation is a process that is intended to lead to a joint effort by stakeholders, technical specialists, the authorities and the proponent/developer who work together to produce better decisions than if they had acted independently.

The public participation process is designed to provide sufficient and accessible information to I&APs in an objective manner in a phased approach as outlined below:

During the Scoping Phase to enable them to:

- Raise issues of concern and suggestions for enhanced benefits;
- Verify that their issues have been recorded;
- Assist in identifying reasonable alternatives; and
- Contribute relevant local information and traditional knowledge to the environmental assessment.

During the Impact Assessment Phase to assist them to:

- Contribute relevant information and local and traditional knowledge to the environmental assessment;
- Verify that their issues have been considered in the environmental investigations; and
- Comment on the findings of the environmental assessments.

During the decision-making phase:

- To advise I&APs of the outcome, *i.e.* the authority decision, and how the decision can be appealed.

6.2 Identification and Registration of Interested and Affected Parties

Interested and Affected Parties (I&APs) were initially identified through a process of networking and referral, obtaining information from Golder's existing stakeholder database, liaison with potentially affected parties in the study area, newspaper advertisements and a registration process involving completion of a registration and comment sheet. The registration sheet encouraged I&APs to indicate the names of their colleagues and friends who may also be interested in participating.

The initial stakeholder database used to announce Africary's proposed UCG and gas-fired power generation project for the application for an EIA and EMP in support of their environmental authorisation process comprised a large number of I&APs representing the various sectors of society listed below.

- Government (national, provincial and local);
- Environmental Non-Governmental Organisations (NGO);
- Conservation Agencies;
- Community Representatives and CBOs;
- Business and Commerce; and
- Other.

The NEMA Regulations (GN R.543) distinguish between I&APs and registered I&APs. I&APs, as contemplated in section 24(4)(d) of the NEMA include: "*(a) any person, group of persons or organisation interested in or affected by an activity; and (b) any organ of state that may have jurisdiction over any aspect of the activity".*

In terms of the Regulations:

"An EAP managing an application must open and maintain a register which contains the names, contact details and addresses of:

(a) All persons who; have submitted written comments or attended meetings with the applicant or EAP;

(b) All persons who; have requested the applicant or 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.

A Register for I&APs was opened and kept updated throughout the EIA process – see APPENDIX A.

6.3 Public participation during the Scoping phase

This section provides a summary of the public participation process followed during the Scoping Phase of the EIAEMPr process.

6.3.1 Announcement of the proposed project

The availability of the Scoping Report was announced on 4 October 2016 and stakeholders were invited to participate in the EIA/EMPr and public participation process and to pass on the information to friends, colleagues and neighbours who may be interested, and to register as I&APs. The Scoping Report, which included the Comment and Response Report, was available for public review for a period of 30 days from Tuesday, 4 October 2016 until Thursday 3 November 2016.

The availability of the Scoping Report was announced as follows:

- Distribution of the Scoping Report and a letter of invitation to participate to all I&APs on the database, accompanied by a registration, comment and reply sheet that was mailed/emailed to the entire stakeholder database. Copies of these documents are attached as APPENDIX B;

- The abovementioned documents were made available on the Golder website www.golder.com/public;
- An advertisement was published in a local newspaper, the Volksblad on 4 October 2016 (APPENDIX C).

After expiry of the comment period, the Scoping Report was finalized and submitted to the Department of Mineral Resources (DMR) on 14 December 2016. The DMR accepted the Scoping Report on 28 April 2017.

6.4 Public Participation during the Impact Assessment Phase

Public participation during the Impact Assessment Phase of the EIA entails a review of the findings of the EIA, presented in the Draft EIA/EMPr Report, and the volume of specialist studies. These reports were made available for public comment from **Friday 19 May 2017 to Wednesday 21 June 2017**. Interested and affected parties could comment in writing (mail, fax or email), or by telephone.

All the issues, comments and suggestions raised during the comment period on the Draft EIA Report/EMP will be added to the Comment and Response Report that will form APPENDIX F to the Final EIA/EMPr Report, whch will then be submitted to the DMR.

6.5 Public Participation during the Decision-making Phase

Once the DMR has taken a decision about environmental authorisation for the proposed project, the Public Participation Office will immediately notify I&APs of this decision and of the opportunity to appeal. This notification will be provided as follows:

- A letter will be sent, personally addressed to all registered I&APs, summarising the authority's decision and explaining how to lodge an appeal should they wish to; and
- An advertisement to announce the Lead Authority's decision will be published in "Die Volksblad" and the "Free State Sun" newspapers.

6.6 Summary of Issues Raised by I&APs

The issues identified by I&APs to date, together with the responses provided by Africary and Golder Associates, are recorded in the Comments and Response Reports (CRR) - see APPENDIX F. The questions asked and issues raised have been separated into relevant categories. Most of the questions and issues relate to the UCG process and its effects on groundwater, air quality and agricultural activities. People also wanted to know about the project's water requirements, job creation, waste management, and general environmental management. Stakeholder consultation is an on-going process throughout the EIA and additional issues and concerns might be identified during the remainder of the EIA process.

7.0 ENVIRONMENTAL ATTRIBUTES AND DESCRIPTION OF THE BASELINE RECEIVING ENVIRONMENT

This section of the report provides a description of the receiving environment and existing pre-project environmental conditions on and in the vicinity of the proposed project area.

7.1 Climate

A brief summary of the key climatic conditions in the project area is provided here. The specialist report on air quality (Allan, C; Coetzee, L;, October 2013) contains more comprehensive information.

The proposed UCG project site is situated in the subtropical high-pressure belt. The mean circulation of the atmosphere over the subcontinent is anticyclonic throughout the year as a result of the semi-permanent South Indian Anticyclone (HP cell), Continental High (HP cell) and the South Atlantic Anticyclone (LP cell) in the high pressure belt located approximately 30°S of the equator. Easterly flows (LP cells) occur from the equator to the southern mid-latitudes. Westerly waves and lows (LP cells) bring cold fronts from the polar region into the mid-latitudes, especially during winter. In summer, the anticyclonic HP belt weakens and shifts southwards, weakening the influence of the westerly wave and lows.

HP cells establish relatively stable atmospheric conditions that are unfavourable for the dispersion of air pollutants, especially when emitted close to the ground. Westerly waves and lows produce sustained uplift, unstable atmospheric conditions that are favourable for air pollutant dispersion, cloud formation and precipitation.

As no meteorological monitoring has been undertaken at the proposed project site, the meteorological information in this section has been sourced from the literature and from long term observations recorded at the two weather stations WELKOM (20 km north-north-east) and VIRGINIA – MUN (25km east-north-east of the power plant site. See Figure 7-1.

Typically, meteorology and ambient air quality data remains valid within about 20 km from a specific meteorological station unless there are major topographical features that could cause significant variances.

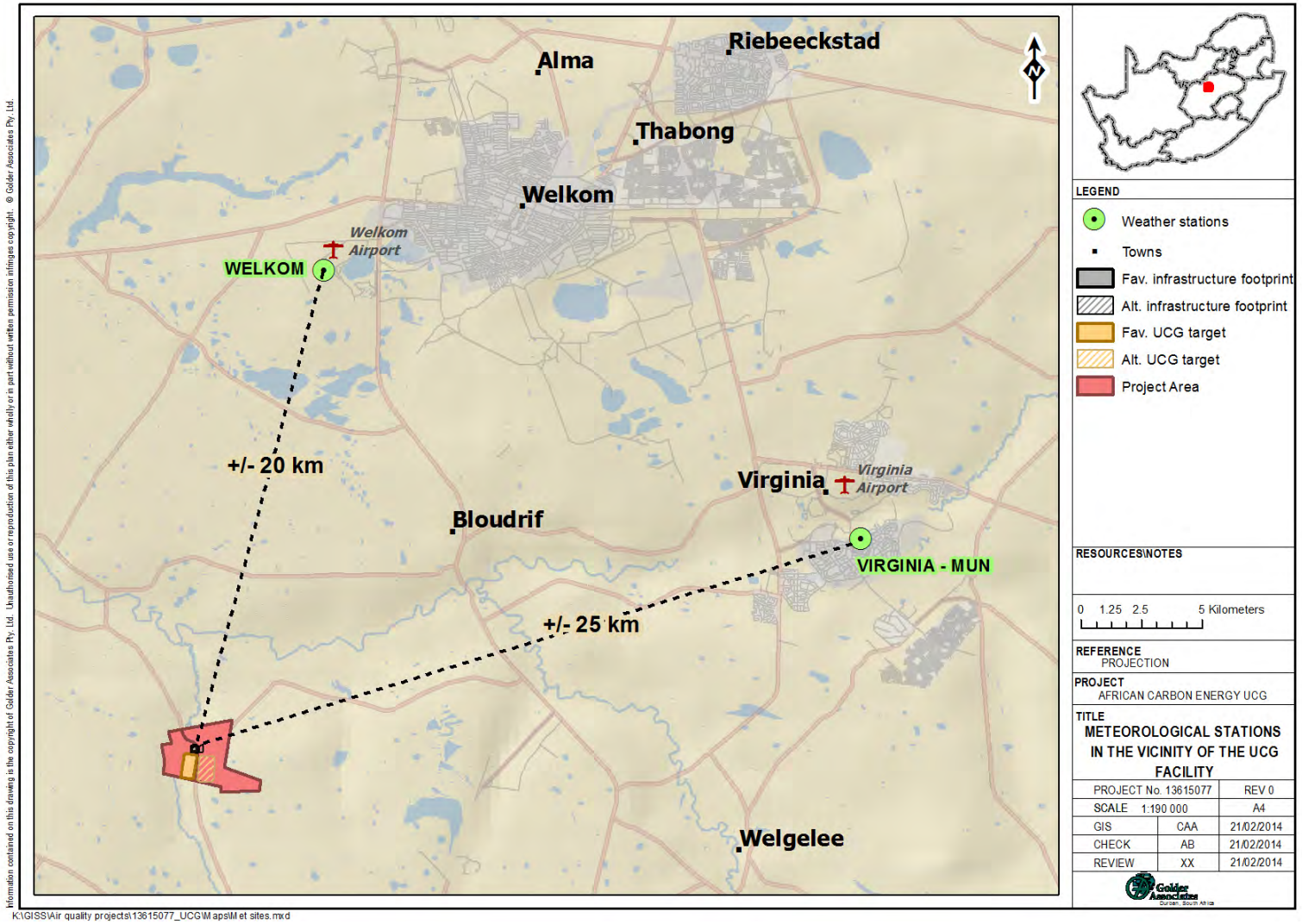


Figure 7-1: Location of the WELKOM and VIRGINIA – MUN meteorological stations in relation to the proposed UCG Facility

7.1.1 Temperature

The project area is characterised by a temperate to warm summer rainfall climate with an overall mean annual precipitation of 530 mm and cold, dry winters. High summer temperatures are prevalent and severe frosts (37 days of the year on average) occur in winter. The monthly average temperatures typical of the site are indicated in Table 7-1.

Table 7-1: Average Monthly Temperature in Project Area

Month	Maximum (°C)	Minimum (°C)
January	30.0	16.7
February	28.4	16.0
March	27.0	14.5
April	23.5	10.7
May	20.7	5.9
June	17.4	2.1
July	18.1	1.9
August	21.1	4.4
September	24.9	8.5
October	26.4	11.6
November	28.2	13.7
December	29.6	15.3

Source: Welkom Weather Station No. 0364300 for period 1930 – 1990

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers. Long term maximum, mean and minimum temperatures for Welkom and Virginia are provided in Figure 7-2.

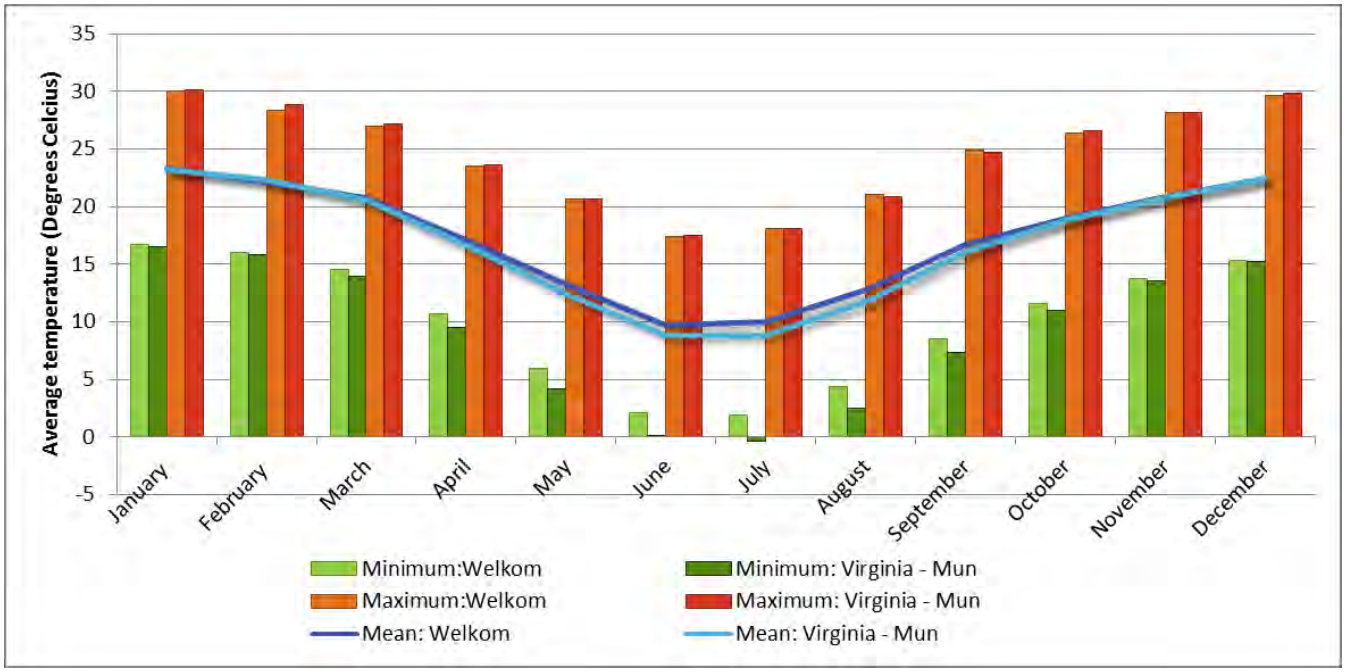


Figure 7-2: Long term average maximum, minimum and mean temperatures for Welkom (1964-1990) and Virginia (1961-1990)

7.1.2 Evaporation

Table 7-2 summarises the average monthly evaporation data in Welkom over a 26-year period (1975 to 2001). The annual average S-pan evaporation value is 2 123mm.

Table 7-2: Annual Average Evaporation in Project Area

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
mm	244.9	196.6	179.1	139.5	113.7	87.3	97.5	140.7	186.9	231	245.7	260.3

Source: Welkom Weather Station No. 0364300 for period 1975 to 2001

7.1.3 Rainfall

Precipitation in the region is often characterised by intense thunderstorms, which occur mainly in the late afternoon, from October to March, with the maximum in January. These thunderstorms, although brief, are often violent, and are accompanied by thunder, lightning and occasional hail, and are generally followed by clear skies. This is reflected in the regional long term average monthly rainfall presented graphically in Figure 7-3.

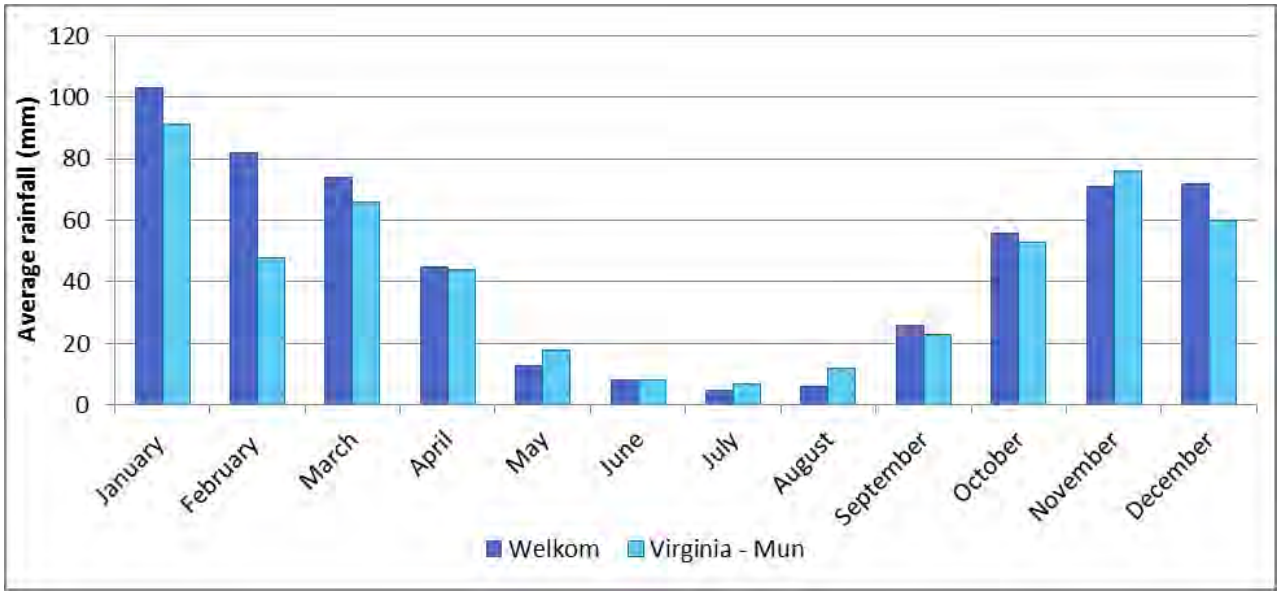


Figure 7-3: Long term average monthly rainfall for Welkom (1964-1990) and Virginia (1961-1990)

Table 7-3 is a summary of precipitation over a 30 year period with maximum values required for project design purposes.

Table 7-3: Precipitation Data Summary

Precipitation Parameter	mm
Average annual rainfall	561
1 in 100 year storm event	N/A*
1 in 50 year storm event	N/A*
Highest recorded rainfall over 1 year	796
Lowest recorded rainfall over 1 year	339
Highest recorded rainfall over 1 month	222
Highest recorded rainfall over a 24 hour period	126

*N/A: Information not available at time of compiling the report

7.1.4 Wind

Wind roses summarise the occurrence of winds at a specified location via representing their strength, direction and frequency. Calm conditions are defined as wind speeds of less than 1 m/s which are represented as a percentage of the total winds in the centre circle. Each directional branch on a wind rose represents wind originating from that specific cardinal direction (16 cardinal directions). Each cardinal branch is divided into segments of different colours which represent different wind speed classes. For the current wind roses, wind speed is represented in classes, 1 to 2 m/s in blue, 2 to 4 m/s in green, 4 to 6 m/s in yellow 6 to 10 m/s in orange, and >10m/s in red. Each circle represents a percentage frequency of occurrence.

The wind field characteristics presented here are based on analysis of the MM5 modelled meteorological data for the years 2008 to 2012.

The annual wind rose for the power plant site is presented in Figure 7-4. Winds originate mostly from the north-east (9.5% of the time) and north-north-east (9% of the time), reaching speeds of up to 10 m/s. Winds are moderate, with 12.88% calms (< 1 m/s).

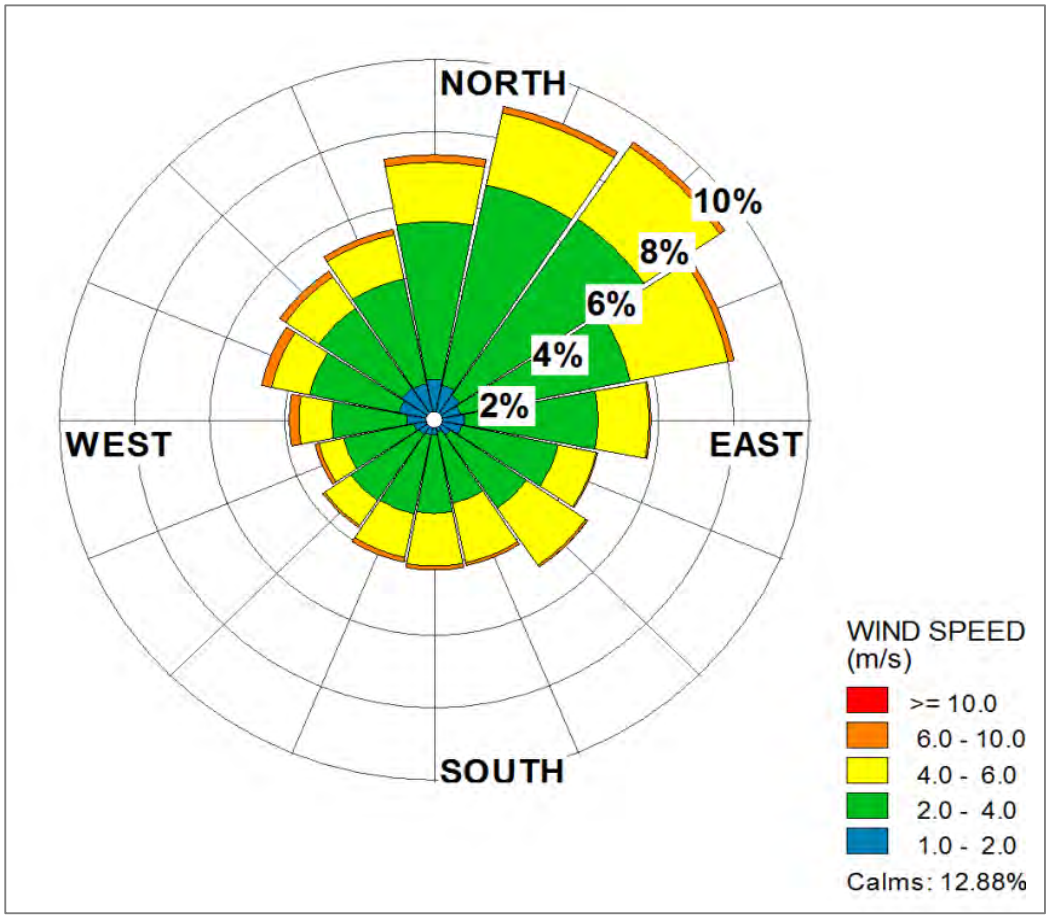
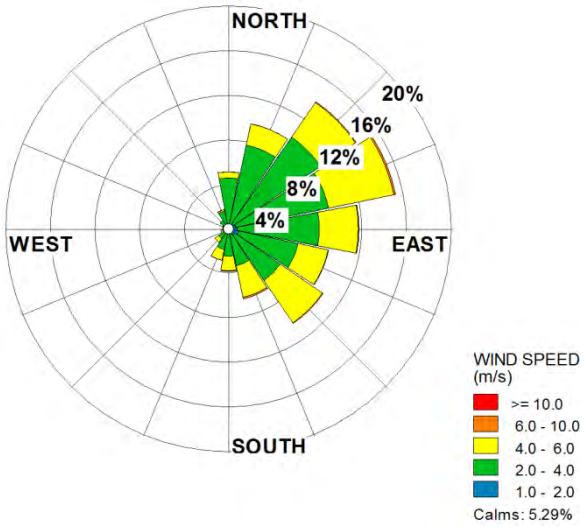


Figure 7-4: Modelled wind rose and wind frequency distribution at the power plant site for the period 2008 to 2012

Diurnal and seasonal wind roses for the modelled wind field at the power plant site are shown in Figure 7-5 and Figure 7-6 respectively.

Comparison of the MM5 modelled wind fields for the power plant site with the recorded data for the weather station at Welkom showed sufficient consistency to provide a high level of confidence in the MM5 modelled data.

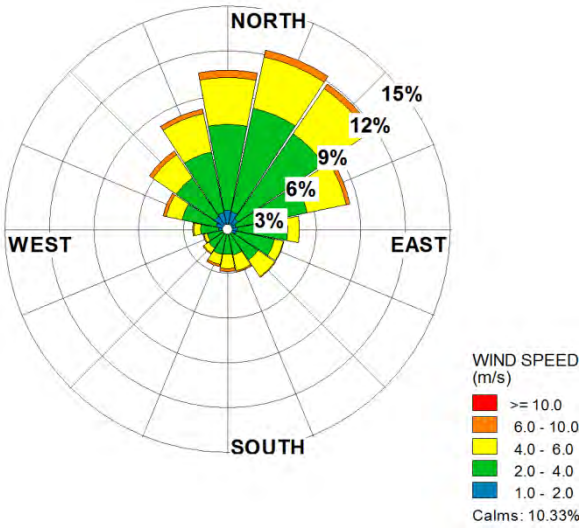


00:00 to 05:59

Calms 5.29% of the time

ENE 15% of the time

NE 14 % of the time

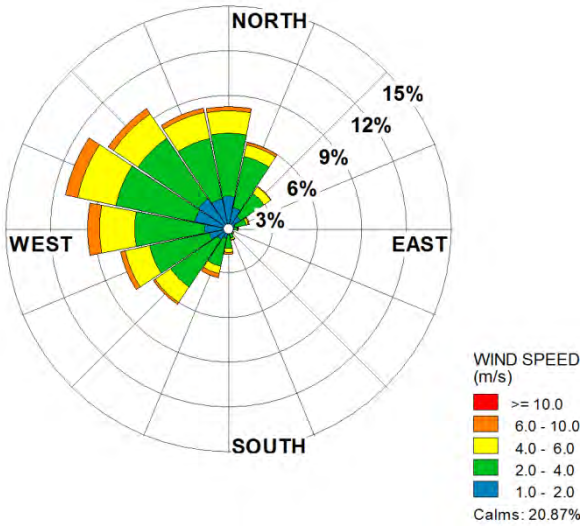


06:00 to 11:59

Calms 10.33% of the time

NNE 12.5 % of the time

NE 12 % of the time

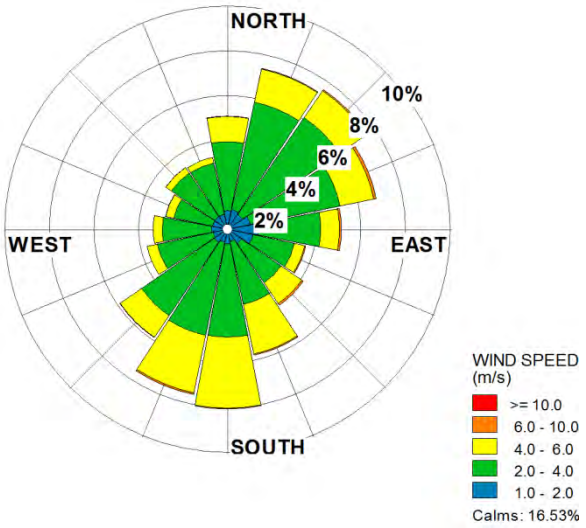


12:00 to 17:59

Calms 20.87% of the time

WNW 11% of the time

W 9.5% of the time



18:00 to 23:59

Calms 16.53% of the time

S 8% of the time

SSW 7.5 % of the time

Figure 7-5: Modelled diurnal wind rose and wind frequency distribution at the power plant site for the period 2008 to 2012

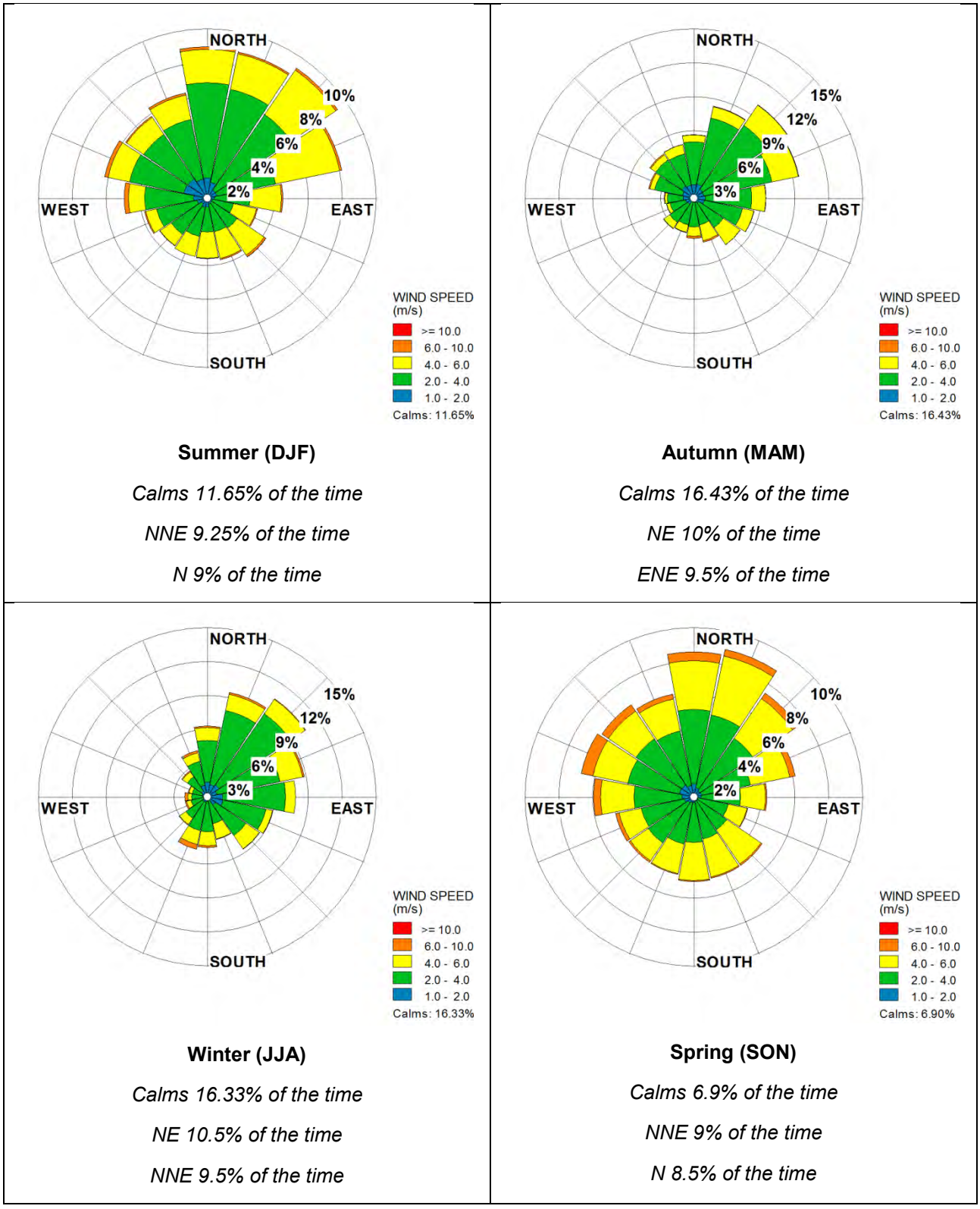


Figure 7-6: Modelled seasonal wind rose and wind frequency distribution at the power plant site for the period 2008 to 2012

7.2 Air Quality

No ambient air quality monitoring is being undertaken at or near the proposed project area, but the Mangaung Local Municipality (MLM) monitors wind speed, wind direction, humidity, temperature, NO_x, CO,

SO_2, PM_{10} and $PM_{2.5}$ at Pelonomi Hospital and Kagisanong and has reported in the region of about 20 exceedances of the daily average standard for PM_{10} concentration, which is the most significant contributor to air pollution in the MLM area. No exceedances of the other criteria pollutants were recorded (Zanokuhle Environmental Services;, August 2009).

However, these stations are about 120 km from the proposed site, significantly more than the 20 km validity threshold, and an assessment of local air quality was based on identified emission sources in the vicinity of the site, namely agriculture, mining, domestic fuel burning, biomass burning, vehicle emissions and vehicle entrainment of dust on unpaved roads.

PM_{10} is likely to be the most prevalent air pollutant in an agricultural area, where air quality is typically dominated by seasonal coarse dust which is often associated with land preparation for cultivation. Biomass burning (veld fires) is also likely to be an important seasonal source of atmospheric particulates and gases. During periods of strong winds, typically towards the end of winter, dust storms can develop from cultivated areas and the tailings dams of the gold mines can also contribute.

Based on available information in the literature and experience of other areas with similar emission sources and climatic conditions, the air quality in the project area is expected to be generally good, with some deterioration during the winter as a result of increased particulate concentrations resulting largely from tilling of fields and biomass burning under dry conditions.

7.3 Noise

A baseline noise survey was undertaken at and in the vicinity of the proposed power plant site towards the end of July 2013. (van der Merwe, B;, December 2013)The site is largely rural in character and baseline noise levels in the area are fairly typical of rural settings with night time noise levels in the order of 35 dBA and day time noise levels of around 45 to 50 dBA, caused mainly by road and farm vehicles, birds, insects and animals. The district roads are unpaved and are used mainly by the local farmers.

7.3.1 Methodology

The noise survey was conducted in terms of the provisions of SANS 10103 of 2008 - The measurement and rating of environmental noise with respect to annoyance and to speech communication and the Noise Control Regulations.

The following equipment was used in the noise survey:

Larsen Davis Integrated Sound Level meter Type 1 – Serial no. S/N 0001072;

Larsen Davis Pre-amplifier – Serial no. PRM831 0206;

Larsen Davis ½" free field microphone – Serial no. 377 B02 SN 102184;

Larsen Davis Calibrator 200 – Serial no.9855.

The instruments used in the noise survey were calibrated before and after the measurements were done and they coincided within 1.0 dBA. The batteries were fully charged and a wind shield was in use at all times.

7.3.2 Baseline noise levels

The locations of farmsteads as sensitive areas were taken into consideration in choosing the measuring points shown in Figure 7-7. The coordinates and descriptions of the measuring points are listed in Table 7-4

Table 7-4: Measuring points

Position	X WGSDD	Y WGSDD	Remarks
1	28^0 10,581 S	026^0 37,117 E	Along the feeder road at the proposed plant site. Traffic noise
2	28^0 10,271 S	026^0 36,705 E	Boundary of UCG study area at the nearest NSA. Traffic noise
3	28^0 10,533 S	026^0 35,310 E	West of the study area. Distant traffic and farming activity noise
4	28^0 11,713 S	026^0 35,731 E	West of the study area. Distant traffic and farming activity noise
5	28^0 11,691 S	026^0 36,430 E	South of the study area. Distant traffic and farming activity noise

Position	X WGSDD	Y WGSDD	Remarks
6	28^0 11,677 S	026^0 37,097 E	Along the feeder road and south of the UCG boundary. Traffic noise
7	28^0 12,477 S	026^0 37,547 E	Along the feeder road. South of the plant. Traffic noise
8	28^0 11,523 S	026^0 38,987 E	Eastern boundary along existing gravel road. Distant traffic and farm noise
9	28^0 11,620 S	026^0 40,115 E	Eastern boundary along existing gravel road. Distant traffic and farm noise
10	28^0 11,874 S	026^0 40,040 E	Eastern boundary along existing gravel road. Distant traffic and farm noise
11	28^0 13,032 S	026^0 40,908 E	Eastern boundary along existing gravel road. Distant traffic and farm noise
12	28^0 09,778 S	026^0 41,138 E	Eastern boundary along existing gravel road. Distant traffic and farm noise
13	28^0 09,247 S	026^0 39,203 E	Eastern boundary along existing gravel road. Distant traffic and farm noise
14	28^0 10,130 S	026^0 38,005 E	Eastern boundary along existing gravel road. Distant traffic and farm noise
15	28^0 06,838 S	026^0 38,479 E	Along the feeder road. Traffic noise

According to the Welkom meteorological weather station (No. 0365400) the prevailing wind direction within the vicinity of the project area is from the north (12%), north-north-east (11.5%) and north-east (10.5%). The noise survey was done during the day (06h00 to 22h00) and night time (22h00 to 06h00) periods. Wind speeds were 0.4m/s to 3.1m/s from the north-west during the daytime and 0.1m/s to 0.5m/s during the night time.

The prevailing noise levels in and around the study area are typical for an agricultural district with a main feeder road and local gravel roads. The prevailing noise sources in the study area and which local residents are already exposed to are:

- Road traffic and overflying aircraft;
- Ploughing of fields and harvesting of crops;
- Animal and insect noises;
- Weather – wind, thunder and rain;

The measured pre-project noise levels at the measuring points indicated in Table 7-4 and Figure 7-7 are listed in Table 7-5. Exceedances of the daytime and night time standards for rural districts as listed in Table 11-12 are highlighted in red.

The maximum levels measured exceeded the standards for rural districts at all the measuring points, but only for very short periods of time. Leq, the integrated sound level over several hours, exceeded the daytime and night time standards for rural districts at measuring points 7 and 15, which are both located along the main feeder road.

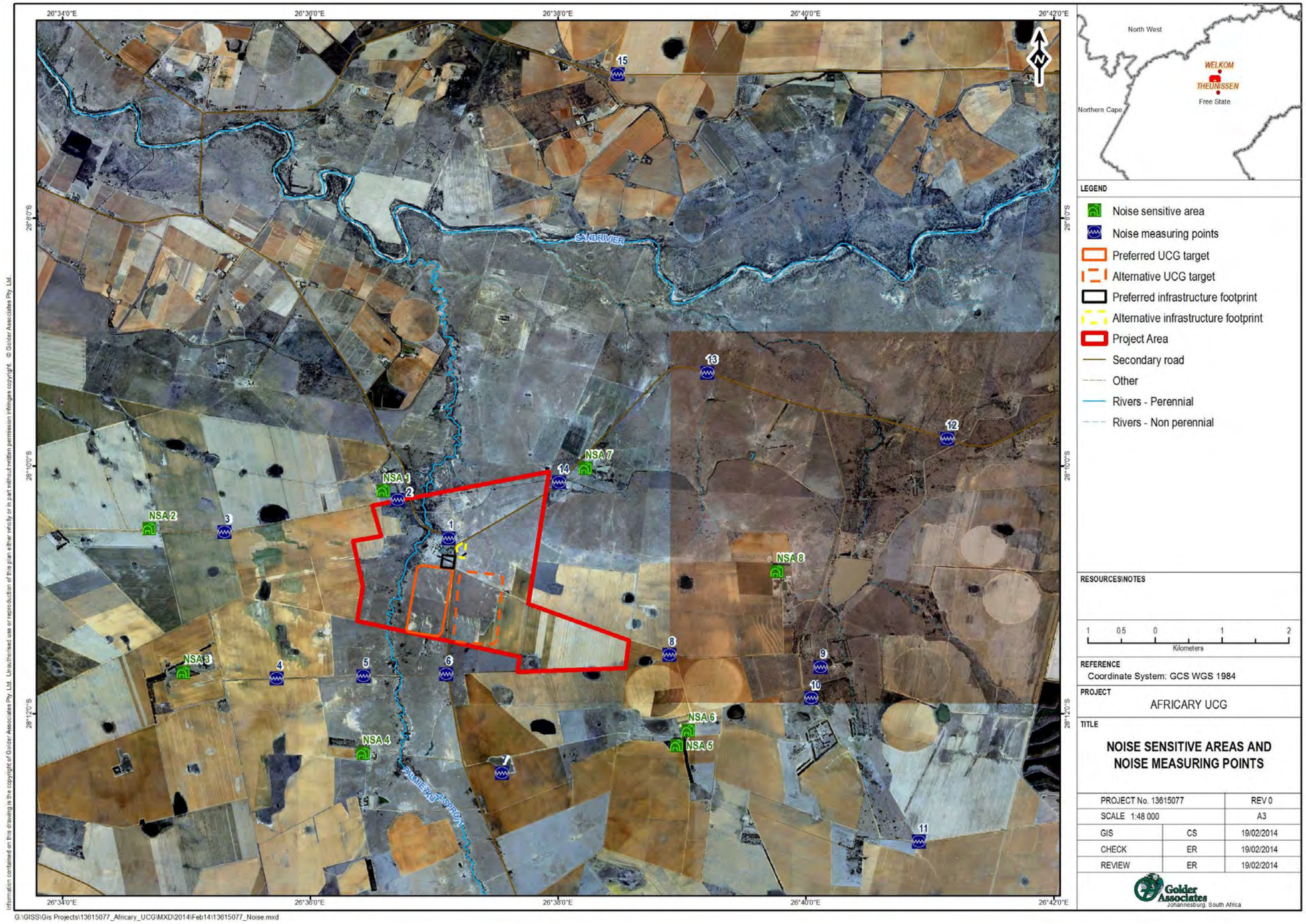


Figure 7-7: Noise sensitive areas and measuring points

Table 7-5: Pre-project noise levels at measuring points

	Daytime				Night time			
Measuring point	**Leq - dBA**	**Lmax - dBA**	**Lmin - dBA**	**Remarks**	**Leq - dBA**	**Lmax - dBA**	**Lmin - dBA**	**Remarks**
1	39.4	55.1	28.2	Traffic not included of which there were 1 tractor and 4 motor vehicles.	25.6	43.7	20.4	Distant ploughing and insects.
2	37.9	61.2	26.2	Wind noise and distant helicopter activities.	23.2	54.5	20.5	Distant insects, but when 2 motor vehicles drove by, the ambient noise level increased to 36.4dBA.
3	38.9	54.1	23.5	Wind and distant farm activities such as ploughing of the fields.	27.2	50.8	20.4	Distant ploughing noise.
4	35.8	54.1	24.5	Wind and distant farm activities such as ploughing of the fields.	27.0	45.7	21.5	Distant ploughing noise.
5	32.3	53.0	25.8	Wind and distant farm activities such as ploughing of the fields.	26.7	49.2	16.9	Distant ploughing noise.
6	29.7	52.3	23.6	Wind and distant farm activities such as ploughing of the fields.	28.9	47.3	20.4	Distant ploughing noise.
7	57.4	85.6	24.9	15m from the edge of the road and 22 vehicles passed the measuring point in an hour.	38.1	72.2	30.8	Distant insects. Two motor vehicles passed the measuring point.
8	35.9	68.0	25.7	Wind and distant farm activities such as ploughing of the fields.	27.3	54.3	20.7	Distant ploughing noise.
9	30.8	52.1	22.7	Wind and distant farm activities such as ploughing of the fields.	27.9	51.9	20.6	Distant ploughing noise.
10	30.7	55.5	24.0	Wind and distant farm activities such as ploughing of the fields.	27.5	44.4	22.0	Distant ploughing noise. Aircraft flew over measuring point and the noise level increased to 44.4dBA.
11	31.6	50.6	28.0	Wind and distant farm activities such as ploughing of the fields.	28.3	46.5	22.9	Distant ploughing noise.
12	31.5	53.4	23.3	Wind and distant farm activities such as ploughing of the fields.	28.4	51.9	20.6	Distant ploughing noise.
13	32.5	49.8	24.2	Wind and distant farm activities such as ploughing of the fields.	26.1	45.9	20.4	Distant ploughing noise.
14	31.0	53.8	21.4	Wind and distant farm activities such as ploughing of the fields.	29.0	61.6	20.4	Distant ploughing noise.
15	53.0	78.7	32.3	Traffic noise and only 3 motor vehicles passed the measuring point in a period of 15 minutes.	36.1	71.2	32.8	Distant insects. One motor vehicle passed the measuring point.

7.4 Topography

Much of the Free State has generally flat to slightly rolling topography, broken only by drainage lines and the occasional flat-topped hills or mesas. Characteristic of the western and north-western Free are natural pan systems, comprising shallow hollows with internal drainage from all sides. These represent important ephemeral sources of brackish to fresh water during and after the rainy season in otherwise largely waterless, semi-arid areas. The project area lies within the Vet and Sand River catchments that can be divided into three parts, namely the eastern highlands where the Sand and Vet Rivers originate, the middle reaches and the western Pedi plains through which the lower parts of the rivers flow until they join downstream of Welkom.

Downstream of this confluence the Vet River flows through undulating plains with a relatively poor drainage until it joins the Vaal River at the Bloemhof Dam. The numerous pans on these undulating plains are indicative of the poor drainage in the region. During floods, the banks of the Sand River, a tributary of the Vet River, are eroded and sandy sediment is transported downstream.

Figure 7-8 indicates that the eastern parts of the Free State are mountainous, while the areas to the west (project area) are relatively flat. On these flat plains indorheic (inward draining) pans are an important hydrological feature. The entire area of origin of the Vet and Sand Rivers is located above an altitude of 1 515 metres above sea level (mamsl). All the tributaries that flow into these rivers in the middle reaches join the rivers above 1 363mamsl. The rest of the area comprises scattered undulating plains with hills and ridges. The hills consist mainly of light-coloured sandstone. Sometimes these hills are intruded by dolerite dykes and sills. The relatively flat topography is suitable for crop farming, which is practiced in about 50% of the area in the form of maize, sunflower and wheat production.

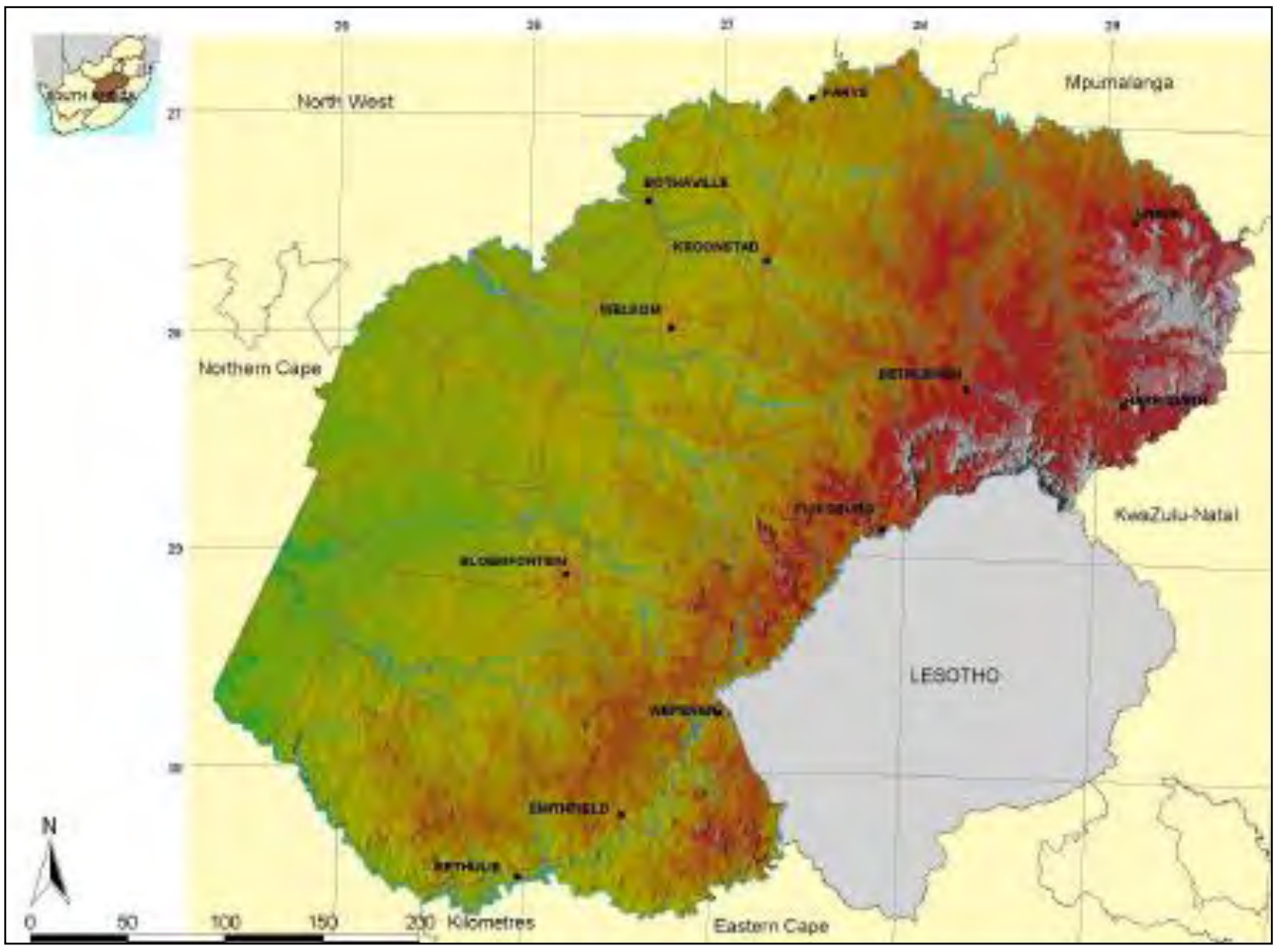


Figure 7-8: Topography of the Free State (DEAT, 2009)

The project area is flat, with an average elevation of 1320 metres above mean sea level (mamsl) and is located in a landscape that is dominated by slightly irregular undulating plains and hills. The Palmietkuil

spruit runs through the project area and the local topography slopes gently towards this small non-perennial stream. The elevation of the Palmietkuil in the southern upper reaches is 1318 metres above mean sea level (mamsl) and it drops in a northerly direction to approximately 1300mamsl over a distance of approximately 3km. The preferred power plant site is located about 200 m east of the Palmietkuil.

7.5 Geology

7.5.1 Regional Geology

The Theunissen project area comprises of two Dwyka-age glacial basins. In the north, the Karoo Supergroup was deposited on volcanics (extrusives) of the Ventersdorp Supergroup and in the south it was deposited on the quartzite of the Witwatersrand Supergroup. The sediments of the Karoo Supergroup generally follow the course of the Vaal River in the north and increase steeply southwards in depth and thickness.

The Karoo sediments in the Theunissen Coal field consist of the Dwyka Formation (diamictites) at the base. This is followed by the coal-bearing Vryheid Formation (Middle Ecca) which is overlain by the shales of the Volksrust Formation (Figure 7-9). The Vryheid Formation consists of a 50 to 90m layer of white to grey fine-grained micaceous sandstones interlaminated with shale bands.

The coal seams in the area are numbered from 1 to 4, with No. 4 being the uppermost. The No. 1 seam occurs at the base of the Vryheid formation in contact with the Dwyka formation. It consists of coal with interbedded pebble bands and has no economic value.

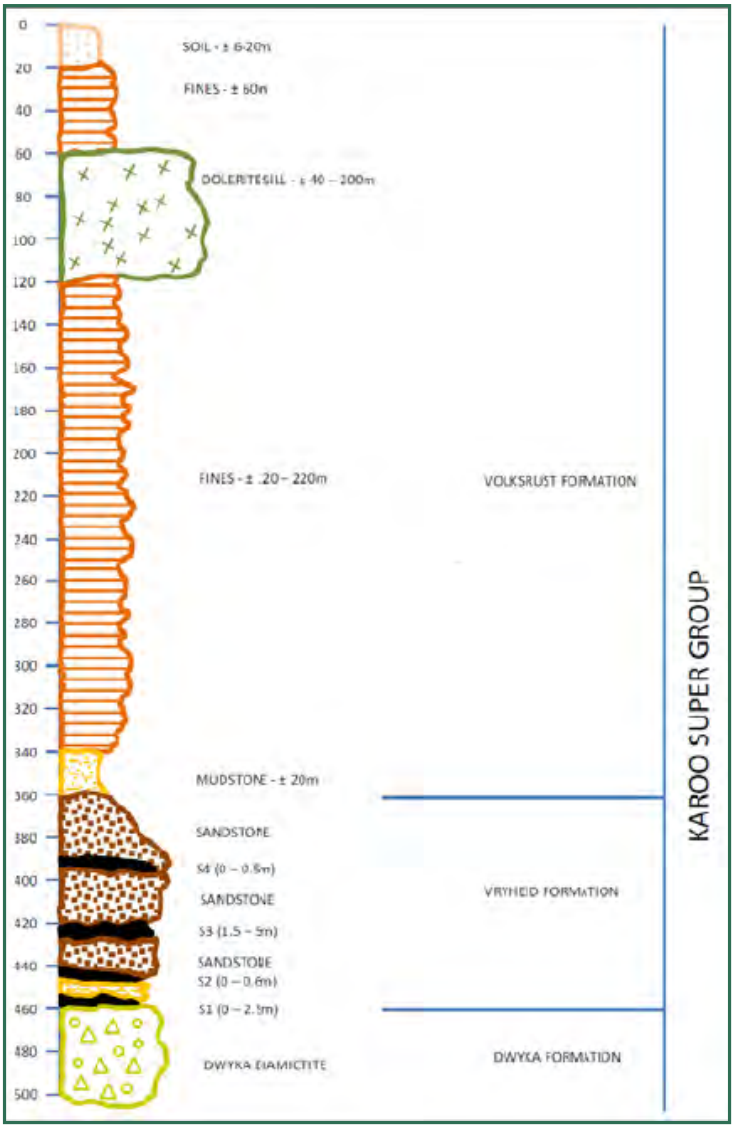


Figure 7-9: Cross section of the Karoo Super Group geology

7.5.2 Local Geology

The coal resource occurs in a palaeo valley which extends in a north-easterly to south-westerly direction. A second valley, which is connected to the northern part of this valley, extends in a westerly direction. The coal field is divided into three blocks or areas, *i.e.* a northern block, western block and southern block. The coal seams are relatively flat to slightly undulating with a south-westerly dip. The average depth to coal is 320m in the north block, 340m in the west block and 380m the south block, becoming more than 500m deep at the southern extreme of the area.

A major dolerite sill, approximately 70m in thickness, overlies the coal seams and generally does not affect the coal seams, except in the eastern area where the dolerite intersects the coal seams, causing them to be uplifted and de-volatilised.

The coal seams in the area are numbered from 1 to 4, with No. 4 being the uppermost. The No. 1 seam occurs at the base of the Vryheid formation in contact with the Dwyka formation. It consists of coal with interbedded pebble bands and has no economic value. The No. 4 and No. 3 coal seams have the greatest

economic value as they are more consistent in terms of coal quality and thickness throughout the coal field. The other seams are restricted to small isolated areas and have thickness constraints, as well as very high ash contents. The No. 3 coal seam gradually thins to the south and changes into carbonaceous shales in the deeper part of the basin. These shales are also associated with deep aquifers.

7.5.3 Coal Specifications

The broad coal specifications in Table 7-6 provide specific geological and hydrological information.

Table 7-6: Coal properties

Resource Property	Units	Value / Comments
Average coal seam thickness	m	3.2
Depth	m	300 – 500
Dip	degrees	3
Parting thickness	m	0
Coal rank	Rank	Bituminous
Thickness competency of consolidated overburden	m	>30
Seam permeability (water influx)	mDarcy	0.01 – 0.001
Distance to nearest overlying water-bearing unit	m	> 200
Overburden drill ability	-	Difficult dolerites

7.6 Soils and land types

7.6.1 Land types

A land type is indicated by an area that can be shown on a map with a scale of 1:250 000. The delineation of land types is determined by a marked degree of uniformity represented by terrain form, soil pattern and climate. The different land types are numbered according to their convenience in a broad soil pattern, e.g. land type Ea39 is the thirty-ninth land type that qualified for inclusion into the broad Ea soil pattern (Agricultural Geo-referenced Information System, 2010).

The study area is located mainly in land type Dc8, presenting as a wide, fairly flat valley bottom dominated by duplex soils of the Valsrivier form that are characterised by a prominent textural contrast between a sandier topsoil and a blocky to prismatic structured subsoil. Other dominant soils are black clay soils of the Arcadia form and alluvial soils of the Oakleaf form.

7.6.2 Classification of Soils

The area is characterised by Aeolian and colluvial sand overlying sandstone, mudstone and shale of the Karoo Supergroup (mostly the Ecca Group) as well as older Ventersdorp Supergroup andesite and basement gneiss in the north. Soil forms are mostly Avalon, Westleigh and Clovelly (Mucina, et al., 2006).

The soils associated with the preferred and alternative power plant sites and UCG target areas (Figure 5-1) were investigated by means of auger holes on 100 m x 100 m grid a to a depth of 1500 mm or to refusal (Steenekamp, P I;, September 2013). A spacing of 150 m was applied along the preferred power line route (Figure 5-5). The soils were described and classified according to the South African Taxonomic Soil Classification System (Soil Classification Working Group, 2nd edition 1991).

The A-horizons (0-250 mm) of the dominant soil types were sampled and analysed at the Institute for Soil, Climate and Water. The analyses were conducted according to methods set out in the Handbook of Standard Testing for Advisory Purposes (Soil Science Society of South Africa, 1990). The following analyses were done:

- Soil acidity (pH) in a 1:2.5 water solution;
- Extractable cations (Na, K, Ca and Mg) according to the ammonium acetate method; and

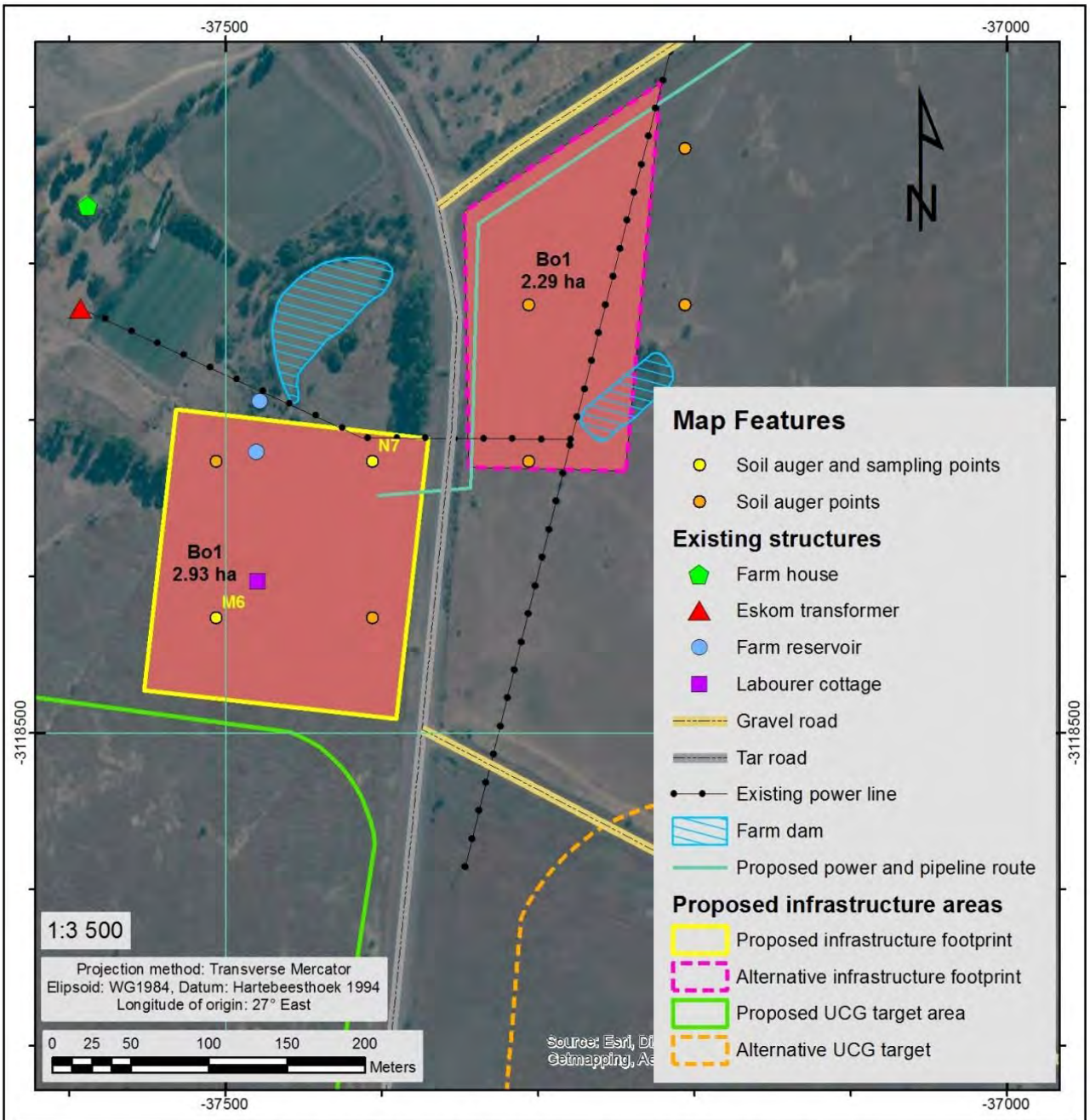
- Phosphorus status according to the Bray 1 method.

Soil types within the proposed and alternative plant footprints were mapped based on soil information gathered from auger observations. A single homogeneous soil unit, based on dominant soil form, effective soil depth, internal drainage, terrain unit and slope percentage was identified as indicated by the symbol Bo1 in Figure 7-10, which contains an abbreviated soil legend. Additional information about this soil type is listed in Table 7-7.

Table 7-7: Soil characteristics -preferred and alternative power plant sites

Soil Type Code	Dominant & subdominant Soil Form and Family	% Clay per horizon A, E, G, B	Summarized description of soil horizons sequences
Bo1	***Bonheim 1120;** Valsrivier 1112, Swartland 11112	A: 35-45 B:40-50	Brown to dark brown, moderate to strongly structured, clay loam to clay Melanic A-horizons underlain by dark brown, strongly structured, clay loam to clay Pedocutanic B-horizons underlain by weathered (soft), white, calcareous rock.

*** Dominant soil form and family**

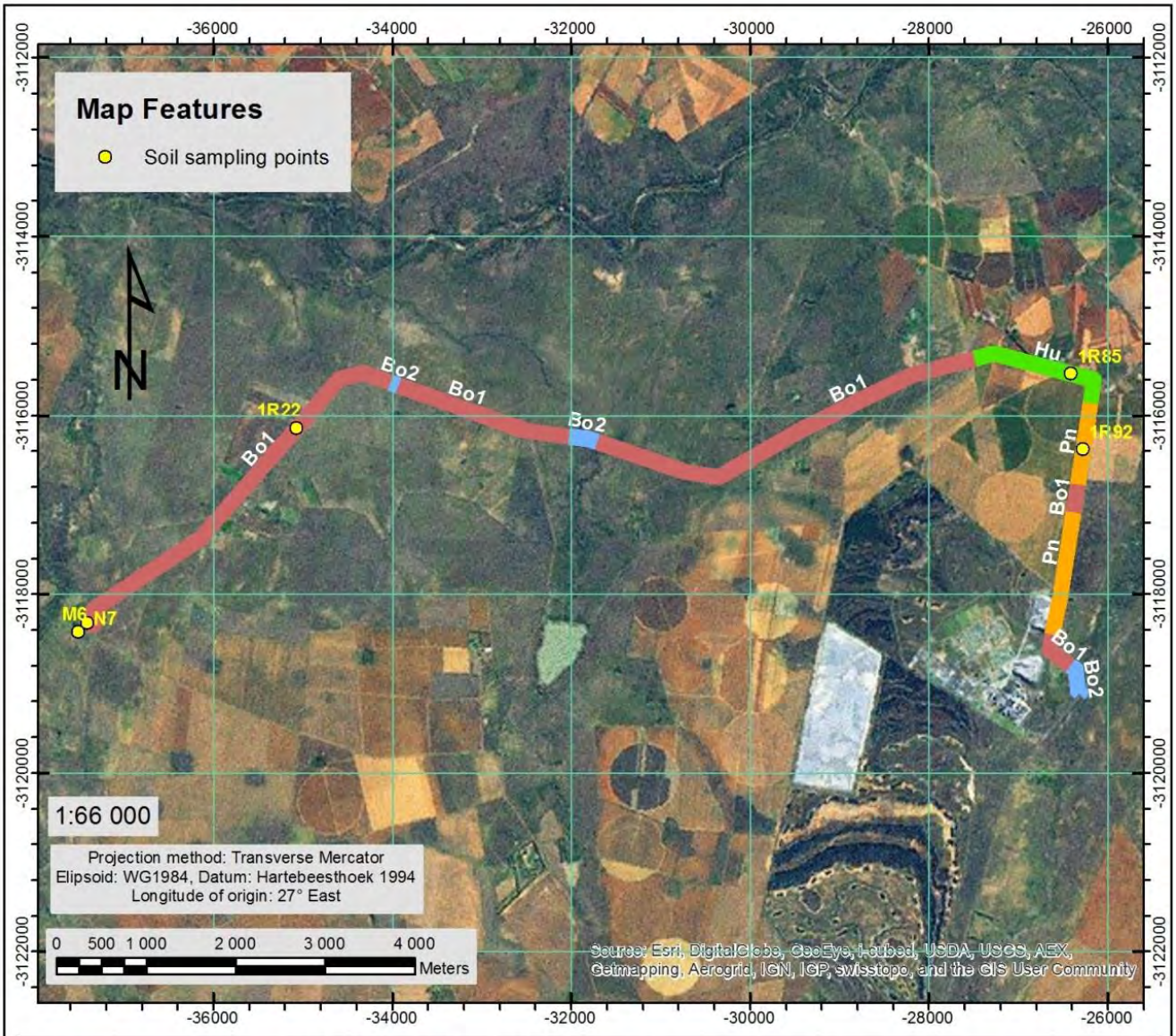


ABREVIATED SOIL LEGEND (See soil report for full soil legend)

Soil Type Code	Dominant & subdominant Soil Form and Family	Summarized description of dominant soil type: Effective depth, terrain unit, slope and erodibility	Agricultural Potential	Land Capability	Wetland zone	Area (ha)	Area (%)
Bo1	***Bonheim 1120;** Valsrivier 1112, Swartland 11112	Shallow to moderately deep (500-900 mm), well-drained, brown to dark brown, structured, calcareous, clay loam to clay soils underlain by soft, weathered calcareous rock on footslopes (2-2.5% slopes); Moderate erodibility.	Moderate to low	Grazing	Terrestrial	5.22	100.0
***Dominant soil form and family**					**Total**	5.22	100.0

Figure 3a: Soil map of the proposed plant and alternative plant footprint of the underground coal gasification project

Figure 7-10: Soil characterisation - preferred and alternative power plant sites



ABREVIATED SOIL LEGEND (See soil report for full soil legend)

Soil Type Code	Dominant & subdominant Soil Form and Family	Summarized description of dominant soil type: Effective depth, terrain unit, slope and erodibility	Agricultural Potential	Land Capability	Wetland zone	Length (m)	Length (%)
Hu	***Hutton 3100;** Clovelly 3100, Avalon 3100	Very deep (>1500 mm), well-drained, yellowish red to red, loamy sand soils on gentle sloping crests (1.5-2% slopes); Low erodibility.	Moderate-high	Arable	Terrestrial	1640.84	9.81
Pn	***Pinedene3100;** Avalon 3100	Shallow (500-600 mm), moderately well-drained, brownish yellow soils underlain by mottled, yellowish grey clay on gentle midslopes (1.5-3% slopes); Low erodibility.	Moderate	Arable	Terrestrial	2317.54	13.86
Bo1	***Bonheim 1120;** Valsrivier 1112, Swartland 11112	Shallow to moderately deep (500-900 mm), well-drained, brown to dark brown, structured, calcareous, clay loam to clay soils underlain by soft, weathered calcareous rock on footslopes (2-2.5% slopes); Moderate erodibility.	Moderate to low	Grazing	Terrestrial	11988.96	71.7
Bo2	***Bonheim 1120;** Sepane, Tukulu, Valsrivier, Oakleaf	Shallow to deep (400-1200 mm), brown to dark brown, structured, calcareous, clay loam to clay soils on flat drainage zones and incised riverbeds (footslopes and valley bottoms, 2-10% slopes); Moderate to high erodibility.	Low to very low	Riparian	Riparian	772.4	4.63
*Dominant soil form and family					Total	16719.74	100.0

Figure 3b: Soil types along the proposed power line and pipeline route of the underground coal gasification project

Figure 7-11: Soil characterisation along preferred power line and pipeline route

Soil types along the proposed power line and pipeline route are shown in Figure 7-11 which contains an abbreviated soil legend. A total of 4 soil types, based on dominant soil form, effective soil depth, internal drainage, terrain unit and slope percentage were identified during field observations and are indicated by the symbols Hu, Pn, Bo1 and Bo2. Additional information about these soil types is listed in Table 7-7.

Table 7-8: Soil types along the preferred power line and pipeline routes

Soil Type Code	Dominant & subdominant Soil Form and Family	% Clay per horizon A, E, G, B	Summarized description of soil horizons sequences
Hu	***Hutton 3100;** Clovelly 3100, Avalon 3100	A: 10-12 B: 12-15	Brownish red, loamy sand Orthic A-horizons underlain by yellowish red to red, loamy sand, apedal B-horizons.
Pn	***Pinedene3100;** Avalon 3100	A:12-15 B: 14-20	Yellowish brown, loamy sand Orthic A-horizons underlain by brownish yellow, loamy sand to sandy loam apedal B-horizons underlain by a mottled yellowish grey clay.
Bo1	***Bonheim 1120;** Valsrivier 1112, Swartland 11112	A: 35-45 B:40-50	Brown to dark brown, moderate to strongly structured, clay loam to clay Melanic A-horizons underlain by dark brown, strongly structured, clay loam to clay Pedocutanic B-horizons underlain by weathered (soft), white, calcareous rock.
Bo2	***Bonheim 1120;** Sepane, Tukulu, Valsrivier, Oakleaf	A: 35-45 B:40-50	Brown to dark brown, moderate to strongly structured, clay loam to clay Melanic A-horizons underlain by dark brown, strongly structured, clay loam to clay Pedocutanic B-horizons underlain by weathered rock or greyish clay layers.
*** Dominant soil form and family**			

7.6.3 Soil chemistry and fertility status

The averaged soil analytical results of representative samples, collected from the A-horizon (0-250 mm) and B-horizons (250-500 mm) are shown in Table 7-9 and compared to soil fertility guidelines (Fertilizer Association of South Africa, 2003). The positions of the sampling points are shown in Figure 7-10 and Figure 7-11.

Table 7-9: Soil chemistry

Soil Horizons	Depth mm	K	Ca	Mg	Na	Resis-tance	P (Bray1) mg/kg	pH (H_2O)
		mg/kg	mg/kg	mg/kg	mg/kg			
		Ammonium acetate				ohm		
Structured clay loam to clay soils - dominant at plant footprint and most of power line and pipeline route								
Average A-Horizons	0-250	404	4345	620	9.7	520	1.6	7.5
Average B-Horizons	250-500	248	7221	733	301	410	1.2	8.4
Apedal loamy sand to sandy loam soils - 24% of power line and pipeline route)								
Average A-Horizons	0-250	290	389	96	1.35	2305	44.2	5.8
Soil Fertility Guidelines	High	<40	<200	<50	<50		<5	
	Low	>250	>3000	>300	>200		>35	

These soils represent the entire preferred and alternative plant footprints and approximately 76% of the soils along the preferred power line and pipeline route.

In the clay loam to clay soils the average values of base cations (K, Ca and Mg) are high and reflect a high natural fertility status. The average sodium (Na) content of 9.7 mg/kg in the A-horizon is low, but it increases to 301 mg/kg in the B-horizon indicating sodic soil conditions and these soils may be prone to erosion once the A-horizon is disturbed. The average pH values of the A and B-horizons of 7.5 and 8.4 respectively indicate slightly alkaline to alkaline soil conditions. The average phosphorus content of the A and B-horizons of 1.6 and 1.2 respectively indicate the general low phosphorus status of natural soils which were not cultivated and fertilised.

The apedal loamy sand to sandy loam soils represent approximately 24% of the soils along the proposed power line and pipeline route. These soils are cultivated and the moderate average values of base cations, together with the high average phosphorus value of 44.2 mg/kg in the A-horizon reflect the effect of fertilisation, since. The average sodium (Na) content of 1.3 mg/kg is low, which is positive and indicates proper internal drainage and absence of sodic soil conditions.

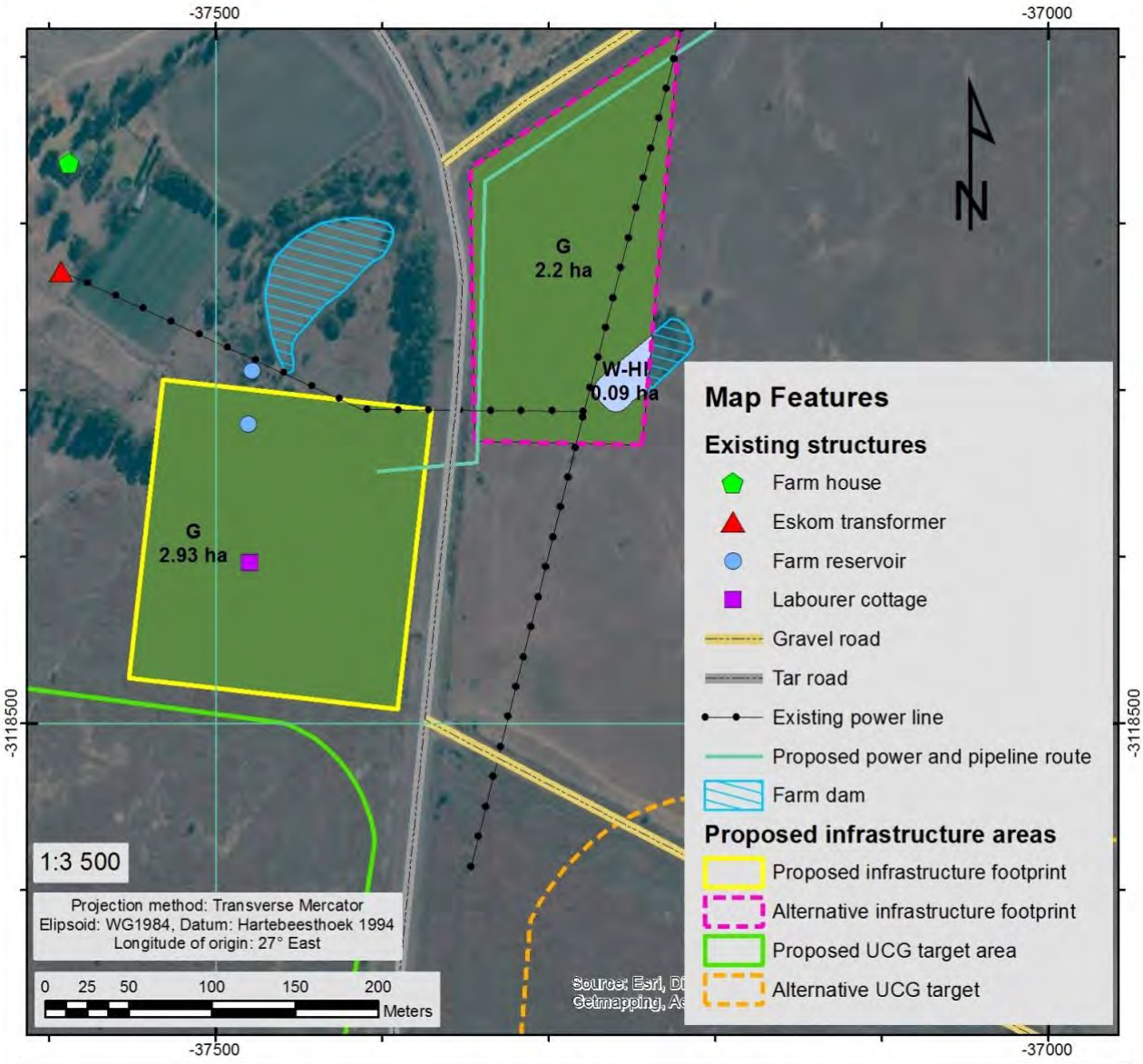
7.6.4 Land capability and land use

The land use in the Middle Vaal WMA is characterised by agriculture with the main irrigation crops being wheat, maize, groundnuts, sorghum and sunflowers. There are also extensive gold mining activities located in the Middle Vaal WMA near Klerksdorp and Welkom, which as a single sector contributes about 45% of the Gross Domestic Product (GDP) in the WMA.

A map of the land capability and pre-project land use at the preferred and alternative power plant sites is shown in Figure 7-12 (Steenekamp, P I;, September 2013).

The grazing potential soils consist of shallow to moderately deep, well-drained, brown to dark brown, structured, calcareous, clay loam to clay soils with moderate erodibility. The grazing potential soils are dominated by the Bonheim and Valsrivier forms, indicated as soil type Bo1 in Figure 7-10.

The land on both sites is currently used for cattle and sheep grazing, with the exception of the small portion shown as a human-induced wetland area on the alternative site. An erosion protection berm was erected on this area and runoff accumulates behind it in the rainy season.



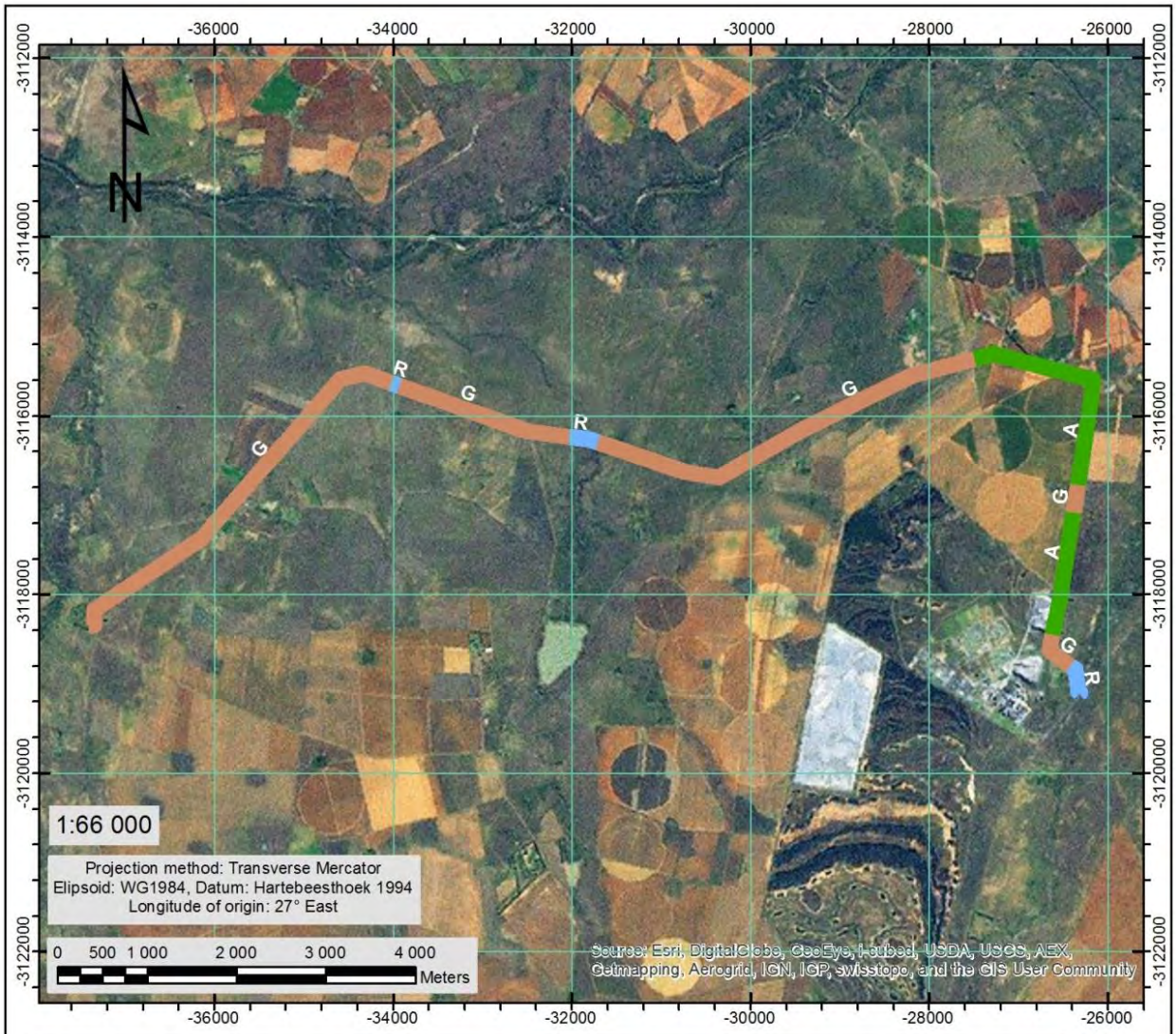
ABBREVIATED LAND CAPABILITY LEGEND

Land capability code	Land Capability Class	*Associated soil type codes	Broad soil description	Area (ha)	Area (%)
A	Arable	-	-	0	0
G	Grazing	Bo1	Shallow to moderately deep (500-900 mm), well-drained, brown to dark brown, structured, calcareous, clay loam to clay soils underlain by soft, weathered calcareous rock on footslopes (2-2.5% slopes); Moderate erodibility.	5.13	98.36
W-HI	Wetland (Human induced)	Bo1	Similar soils as in surrounding area (Bo1). A human induced wetland consisting of a shallow excavated area and berm functioning as an erosion prevention structure where surface runoff accumulates behind.	0.09	1.64
WDN	Wilderness	-	-	0	0
*See soil map Figure 3a			Total	5.22	100.0

Figure 4a: Land capability map of the proposed plant and alternative plant footprint of the underground coal gasification project

Figure 7-12: Land capabilty and land use at preferred and alternative power plant sites

The land capability along the preferred power line and pipeline route is shown in Figure 7-13.



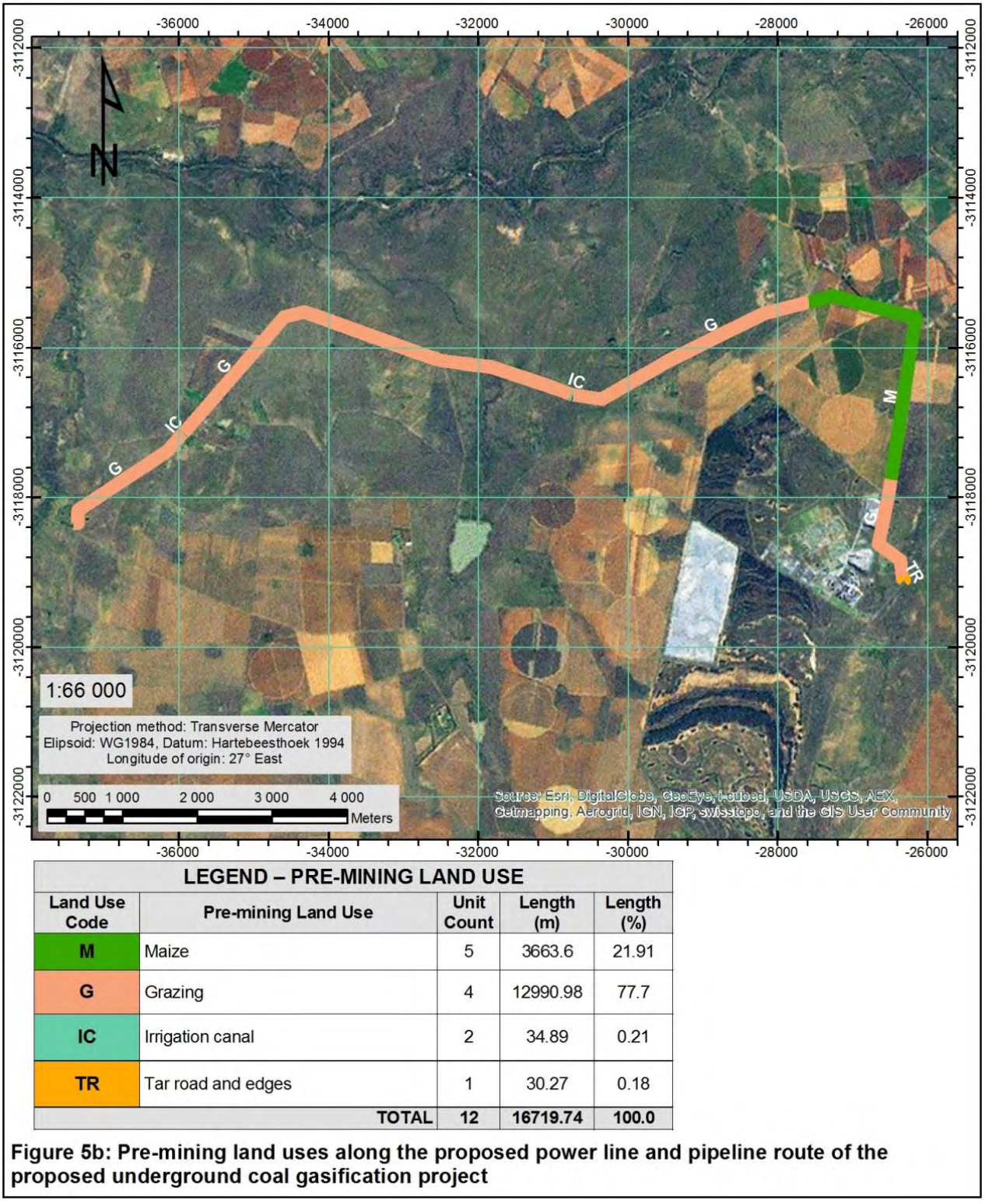
ABBREVIATED LAND CAPABILITY LEGEND

Land capability code	Land Capability Class	Associated soil type codes	Broad soil description	Length (ha)	Length (%)
A	Arable	Hu, Pn	Very deep (>1500 mm), well-drained, yellowish red to red, loamy sand soils on gentle sloping crests (1.5-2% slopes); Shallow (500-600 mm), moderately well-drained, brownish yellow soils underlain by mottled, yellowish grey clay on gentle midslopes (1.5-3% slopes).	3958.38	23.67
G	Grazing	Bo1	Shallow to moderately deep (500-900 mm), well-drained, brown to dark brown, structured, calcareous, clay loam to clay soils underlain by soft, weathered calcareous rock on footslopes (2-2.5% slopes).	11988.96	71.7
R	Riparian	Bo2	Shallow to deep (400-1200 mm), brown to dark brown, structured, calcareous, clay loam to clay soils on flat drainage zones and incised riverbeds (footslopes and valley bottoms, 2-10% slopes); Moderate to high erodibility.	772.4	4.63
WDN	Wilderness	-	-	0	0
			Total	16719.74	100.00

Figure 4b: Land capability along the proposed power line and pipeline route of the proposed underground coal gasification project

Figure 7-13: Land capability map - power line and pipeline route

The pre-project land use along the preferred power line and pipeline route is shown in Figure 7-14.



LEGEND – PRE-MINING LAND USE

Land Use Code	Pre-mining Land Use	Unit Count	Length (m)	Length (%)
M	Maize	5	3663.6	21.91
G	Grazing	4	12990.98	77.7
IC	Irrigation canal	2	34.89	0.21
TR	Tar road and edges	1	30.27	0.18
	TOTAL	12	16719.74	100.0

Figure 5b: Pre-mining land uses along the proposed power line and pipeline route of the proposed underground coal gasification project

Figure 7-14: Pre-project land use map - power line and pipeline route

About 24% (3958 m) of the soils along the power line and pipeline route are classed as arable land with moderate to high agricultural potential. The arable soils consist of red and brownish yellow, well and

moderately well-drained, loamy sand to sandy loam soils, dominated by Hutton and Pinedene soil forms, indicated as soil types Hu and Pn in Figure 7-11.

About 72% (11989 m) is classed as grazing potential. The grazing potential soils consist of shallow to moderately deep, well-drained, brown to dark brown, structured, calcareous, clay loam to clay soils with moderate erodibility, dominated by the Bonheim and Valsrivier forms, shown as soil type Bo1 in Figure 7-11.

The remainder (772 m) is classed as riparian zones, which consist of shallow to deep, brown to dark brown, structured, calcareous, clay loam to clay soils on flat drainage zones and incised riverbeds with moderate to high erodibility. The riparian soil is dominated by Bonheim and Valsrivier soil forms, shown as soil type Bo2 in Figure 7-11.

Approximately 21.9% of the soils along the preferred power and pipeline route are utilized for maize production, 77.7% for grazing, while 0.21% are occupied by irrigation canals and 0.18% by a tarred road.

7.7 Surface Water

The general background information presented in sections 7.7.1 and 7.7.2 below was obtained from literature sources.

7.7.1 Water Management Area

The project area is located in the Water Management Area (WMA) 9: Middle Vaal that is situated in the Free State and North West Provinces in the central part of South Africa. This WMA is situated between the Upper Vaal and Lower Vaal WMA and also borders on the Crocodile (West) and Marico as well as the Upper Orange WMA Figure 7-15. The Vaal River is the main river in the water management area. It flows in a westerly direction from the Upper Vaal WMA to be joined by the Skoonspruit, Rhenoster, Vals and Vet Rivers as main tributaries from the Middle Vaal WMA, before flowing into the Lower Vaal WMA at Bloemhof Dam and then into the Orange River.

To enable improved representation of the water resources situation in the WMA and to facilitate the applicability and better use of information for strategic management purposes, the WMA was divided into sub-areas which have been further divided into sub-catchment areas. The project falls within the Sand / Vet sub-area and within the quaternary catchment C42L (Figure 7-15). The estimated base flow in this quaternary catchment is 2 million m^3/annum (Basson, M S; Rossouw, J D;, 2003). The footprint of the preferred project target area is located across the smaller Palmietkuil stream and adjacent to the Sand River that flows westwards into the Vet River. Vlei areas occur along the lower Vet River.

Table 7-10: Surface water features relevant to project area

Water Management Area	Middle Vaal (WMA 9) (refer to *Figure 7-15*).
Catchment	Middle Vaal WMA comprises 3 sub-areas, *i.e.* the Rhenoster/Vals, Middle Vaal and Sand/Vet sub-areas. Study area is located in quaternary catchment C42L in the Sand River Catchment.
Main water courses	Vaal River in Water Management Area, Sand River and Vet River in Sand / Vet sub-region.
Dams	Vaal River flows into Bloemhof Dam, Allemanskraal Dam on the Sand River and Erfenis Dam on the Vet River.

There are no distinct geographic or topographic features in this WMA and surface runoff is low. Vegetation is mainly grassland, with sparse bushveld in patches. The topography is relatively flat with no distinct features. Hilly terrain occurs to the south-east. The geology is varied, which also gave rise to different soil types. A large dolomitic formation occurs from Orkney and extends towards the northern part of the water management area. Diamonds are found in the north-west of the water management area and gold-bearing strata in the vicinity of Klerksdorp and Welkom. The Allemanskraal game reserve is the best known reserve in the WMA. Some smaller conservation areas are also to be found.

Figure 7-15: Base Map of Middle Vaal Water Management Area (DWAF, 2004) (red square indicates project area)

The Middle Vaal WMA comprises 3 sub-areas, *i.e.* the Rhenoster/Vals, Middle Vaal and Sand/Vet sub-areas. These sub-areas have been further subdivided into sub-catchments for the purpose of highlighting local

issues. The Sand/Vet sub-area is of relevance to this project and includes the following sub-catchments (Basson, M S; Rossouw, J D;, 2003):

Allemanskraal sub-catchment

This sub-catchment is located upstream of Allemanskraal dam and is rural in nature. The bulk of the yield in the catchment is generated in Allemanskraal Dam and is utilised downstream in the Sand River, which is located in the Vet sub-catchment. Senekal is the most important urban centre in the area and is supplied from the Syferfontein and De Put Dams. Consumptive requirements by urban and rural users make up the rest of the requirements. Irrigation water requirements are not significant. The potential for surface water resources development within this area is limited and would impact on downstream users.

Erfenis sub-catchment

This sub-catchment is located upstream of the Erfenis Dam and is rural in nature, with Winburg and Marquard being the most important urban centres in the area. Consumptive requirements by urban and rural users make up 31% of total requirements. There is a transfer of water from the Erfenis Dam to Brandfort in the Upper Orange WMA. Irrigation water requirements are not significant. This sub-catchment contributes to the downstream yield of the Vet River. The available resources upstream of the Erfenis Dam, as well as the storage provided by the Erfenis Dam in this sub-area, have been allocated mainly for irrigation requirements that are located in the downstream Vet sub-catchment. The potential for surface water resources development within this area is limited and would impact on downstream users.

Vet sub-catchment

The main urban centres are Welkom and Virginia and the main mines in this sub-catchment are Harmony, President Steyn, African Rainbow Minerals and Bambanani Gold Mines. Return flows from these users contribute about 10% to the water resources of the sub-catchment. Sedibeng Water has a significant network of reservoirs, pump stations and pipelines from the Vaal River to these main centres. The mining (30%) and urban water requirements (24%) of the Free State Goldfields dominate the water requirements of this sub-catchment. Irrigation water requirements (40%) for controlled irrigation is significant and are the most important in the WMA as a whole. Approximately 122 km^2 is scheduled for irrigation in three areas, namely Sand-Vet GWS (Sand), Sand- Vet GWS (Vet) and Vet River GWS. Due to the significant irrigation requirements this sub-catchment does not contribute to the yield of the Lower Vaal WMA. Sedibeng Water has an allocation of 12 million m^3/a from the Allemanskraal Dam (Basson, M S; Rossouw, J D;, 2003).

7.7.2 Surface Water Resources

A specialist surface water study specific to the project area was undertaken during August 2013 (Cassa, A; Coleman, T;, February 2014).

The surface water availability in the Vaal River System is estimated through a set of water resource models, each fulfilling a particular function in the management of the water resources. Combined, these models serve as a decision support tool that contains a large and comprehensive database of hydrological and physical system characteristics, required to simulate the water resource systems as realistically as possible.

The Middle Vaal WMA is dependent on releases from the Upper Vaal WMA for meeting the bulk of the water requirements of its urban, mining and industrial sectors. Releases from the Upper Vaal WMA in support of the Lower Vaal WMA are transferred via the Middle Vaal WMA to the Bloemhof Dam, which is the uppermost control structure in the Lower Vaal area. Management of water quantity and quality in the Middle Vaal WMA is therefore integrally linked to both the Upper Vaal and Lower Vaal WMA and commensurate management approaches will have to be followed in these water management areas. It is appropriate therefore that these aspects are managed at a national level.

Surface water flows which originate within the water management area are highly seasonal and variable, with flow in many of the tributaries intermittent. The flow in the Vaal River, most of which originates in the Upper Vaal WMA, represent the bulk of the surface water in the Middle Vaal WMA. The closest flow monitoring station is at Bloudrift on the Sand River, approximately 10km upstream of the preferred target area (Table 7-11).

Table 7-11: Nearest DWAF flow monitoring station

Monitoring Station	Catchment Area	Latitude	Longitude	Monitoring Period
C4H016EC Sand River @ Bloudrif	7 092 km^2	28.11722	26.71917	20/11/1995 to 22/01/2013

Dams have been constructed on all the main tributaries of the Vaal River. Any unregulated runoff is controlled by the Bloemhof Dam on the Vaal River in the Lower Vaal WMA immediately after the river exits the Middle Vaal WMA. No realistic potential for further development of surface water exists. The main storage dams of relevance to this project are the Allemanskraal Dam on the Sand River and Erfenis Dam on the Vet River in the Sand-Vet sub-area. Bloemhof Dam is located on the Vaal River immediately below the confluence of the Vet River. The dam structure is in the Lower Vaal WMA, although most of the reservoir falls within the Middle Vaal WMA. The dams on the tributaries are operated independently from the Vaal River, although flood spillage from the dams and flow from unregulated tributaries are captured at Bloemhof Dam at the downstream end of the WMA.

The full yield from the local surface runoff is used within the WMA, mostly for irrigation, but with a large proportion also for urban supplies to towns in the WMA. Extensive use of groundwater for rural domestic and village supplies is made throughout the Middle Vaal WMA. Owing to the decline in gold mining activity, a small decrease in population is projected for the area, with concomitant effects on economic activity. Little change in water requirements is therefore expected.

A summary of the natural mean annual runoff (MAR), together with the estimated requirements of the ecological component of the Reserve, is given **Table 7-12**.

Table 7-12: Mean Annual Runoff & Ecological Reserve (million m3/a) for Sand/Vet sub-area (DWA, 2004)

Component / Sub-area	Natural MAR[1]	Ecological Reserve[1,2]
Rhenoster-Vals	295	35
Middle Vaal	170	29
Sand / Vet	423	45
Total for WMA	**888**	**109**

1) Quantities are incremental and refer to the sub-area under consideration only.

2) The total volume is based on preliminary estimates, with impact on yield being a portion of this.

The negative contribution from surface resources in the Middle Vaal sub-area (**Table 7-13**) is a result of evaporation losses along this reach of the Vaal River being in excess of the yield from local tributaries. Owing to the intermittent nature of flow in the tributary rivers, provision for the ecological component of the Reserve has relatively little impact on the yield from the Rhenoster/Vals and Sand/Vet sub-areas.

Table 7-13: Available yield in the year 2000 (million m³/a) (DWAF, 2004)

Component/ Sub-area	Natural resource		Usable return flow			Total local yield
	Surface water[1]	Groundwater	Irrigation	Urban	Mining and bulk	
Rhenoster-Vals	22	12	3	7	0	**44**
Middle Vaal	(201)	25	3	15	16	**(142)**
Sand-Vet	112	17	10	7	1	**147**
Total for WMA	**(67)**	**54**	**16**	**29**	**17**	**49**

1) After allowance for the impacts on yield of the ecological component of the Reserve, river losses, alien vegetation, rain-fed sugar cane and urban runoff.

The quality of surface water in the water management area is good, but it can at times have high turbidity. Human activities within the Middle Vaal WMA are generating substantial return flow volumes in the form of treated effluent from the urban areas and mine dewatering that are discharged into the river system. These discharges are having significant impacts on the water quality in the main stem of the Vaal River.

Wash-off and return flows from urban areas in the proximity of the Vaal River and main tributaries, such as at Klerksdorp, also impact on water quality. Water that enters the Middle Vaal WMA along the Vaal River contains a large proportion of urban and industrial return flows from the Gauteng area with part of the water having been through more than one cycle of use. As a consequence, salinity levels can be elevated and need to be managed through blending with fresh water in the Upper Vaal WMA, so as not to exceed certain target concentrations. High nutrient concentrations also occur as a result of the large domestic component of return flows which, together with the low turbidity of the return flows, stimulates excessive algal growth.

7.7.3 Rainfall and evaporation

Rainfall data for seven rainfall stations in the area around the Africary site (Kunz, 2004) is shown in Table 7-14.

Table 7-14: Available rainfall data in project area

Station	Name	Length of record	Years of data	Distance and direction from site (km)	Altitude (mamsl)	MAP (mm)
0328159_W	Voorspoed (IRR)	January 1901 to August 2000	99	3.70 NW	1301	428.40
0328187_W	Bryan (IRR)	January 1901 to August 2000	99	5.29 NE	1288	404.31
0328308_W	De Klerks Kraal	January 1901 to August 2000	99	5.53 ENE	1302	441.82
0328308_A	Welkom Sandvet	January 1901 to June 2013*	112	22.05 W	1298	477.52
0327883_W	Grootkuil	January 1901 to August 2000	99	13.78 WSW	1302	482.37
0328347_W	Avondrust	January 1901 to August 2000	99	14.84 SSE	1385	470.21
0328425_W	Adamsonsvlei	January 1901 to August 2000	99	16.63 NE	1342	502.13

*this station has data combined from the (Kunz, 2004) until August 2000 and the ARC Institute for Soil, Climate and Water (Agricultural Research Council (ARC), n.d.) from January 2002 until June 2013.

The Welkom Sandvet Rainfall Station (0328208_A) has the longest and most detailed rainfall record data from this station was used to calculate the 1:50 and 1:100 recurrence rainfall depths. Analysis of the long term record showed that:

- The mean annual rainfall for Welkom SandVet over the 112 year period was 477.52 mm.
- The lowest rainfall year was 1948 with 149 mm
- The highest rainfall year was 2008 with 2111 mm.
- The rainfall was lower than 239 mm/annum for 5 % of the time;
- The rainfall was lower than 457 mm/annum for 50 % of the time;
- The rainfall was lower than 735 mm for 95 % of the time;
- Rainfall events exceeding 50 mm/day occurred 67 times; and
- Rainfall events exceeding 100 mm/day occurred 9 times.

The 24-hour rainfall depths for the 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100 and 1 in 200 recurrence intervals at the Welkom Sandvet station were obtained from the *Design Rainfall Estimation in South Africa*

programME (Smithers & Schulze, 2002). The 24 hour rainfall depths for the Welkom Sandvet station are summarised in Table 7-15.

Table 7-15: 24 hour storm rainfall depths for Welkom Sandvet

Recurrence Interval (years)	1 in 2	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200
Rainfall depth (mm)	62.5	99.9	114.8	135.2	151.2	167.6

7.7.4 Evaporation

Monthly evaporation data for the DWA station C4E009 Zeebrugge at Sand-Vet Sentrum for the period February 1972 to February 2005 is shown in Figure 7-16. Table 7-16 shows the A-Pan and S-pan data from station C4E009 that has been converted for use in open water evaporation.

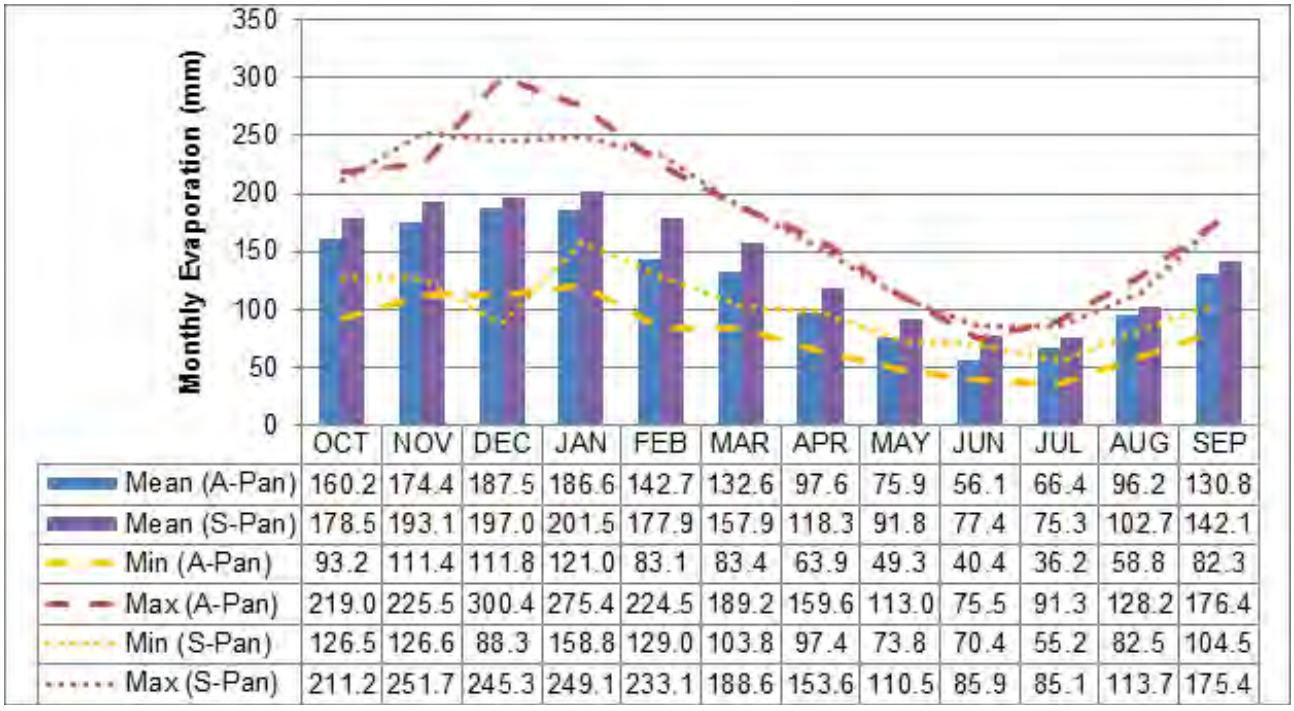


Figure 7-16: Evaporation data for station C4E009 Zeebrugge at Sand-Vet Sentrum

Table 7-16: Monthly open water evaporation from station C4E009 and WR90

Month	C4E009 Original A - pan	C4E009 Original S - pan	WR90 (Open water)
Oct	160.2	178.5	183.9
Nov	174.4	193.1	211.7
Dec	187.5	197.0	247.6
Jan	186.6	201.5	244.8
Feb	142.7	177.9	189.1
Mar	132.6	157.9	162.3
Apr	97.6	118.3	104.8
May	75.9	91.8	72.5
Jun	56.1	77.4	47.4
Jul	66.4	75.3	57.2

Month	C4E009 Original A - pan	C4E009 Original S - pan	WR90 (Open water)
Aug	96.2	102.7	88.7
Sep	130.8	142.1	139.2
Total	**1507.0**	**1713.7**	**1749.1**

7.7.5 Baseline Flow and Water Quality

The Palmietkuilspruit experiences seasonal flow and there are no flow monitoring stations in the spruit itself (Department of Water Affairs, 2011). The Sand River is perennial, with high seasonal variations in flow rate. See Figure 7-17.

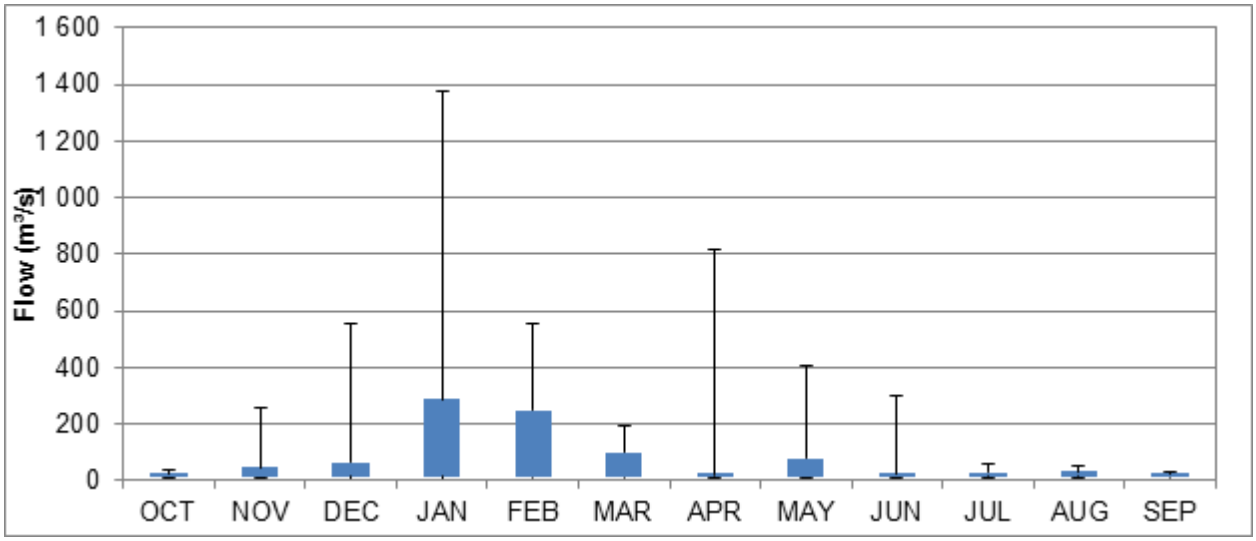


Figure 7-17: Box plot for flow monitoring station C4H016 Sand River at Bloudrif

Figure 7-18 shows the locations of the two flow monitoring and six water quality monitoring stations in the Sand River in the vicinity of the power plant site. Table 7-17 lists the properties of the flow monitoring stations while Table 7-18 provides information about the surface water quality in the area. It indicates whether the station is upstream (US) or downstream (DS) of the confluence of the Palmietkuilspruit and the Sand River, the distance to the Africary site and the dates the stations were monitored.

Table 7-17: Flow monitoring stations in the Palmietkuilspruit area

Station	Station name	Catchment area (km²)	Distance from site (km)	US or DS from Palmietkuilspruit	Dates monitored
C4H016	Sand River at Bloudrif	7092	13.12	Upstream	1995 – 2012
C4H017	Doring River at Mond van Doorn Rivier	586.35	13.74	Upstream	1996 – 2013

Table 7-19 shows the water quality in the Sand River in comparison with the South African Water Quality Guidelines for Domestic Users (Department of Water Affairs and Forestry, 1996). The area is used primarily for agricultural purposes, but the domestic water quality guidelines are more stringent.

Some samples showed high electrical conductivity and total dissolved solids (TDS) that exceeded the drinking water quality guidelines, but were within the limits for livestock watering and crop irrigation. The water is brackish due to the relatively high chloride and sodium content. Calcium and magnesium can also determine the suitability of water for use in agriculture and whilst the magnesium is not a problem, the calcium exceeded the domestic guidelines in some instances. There is no specific limit for total alkalinity, but values above 150 mg/l indicate that the water could require treatment to render it fit for use in a power plant.

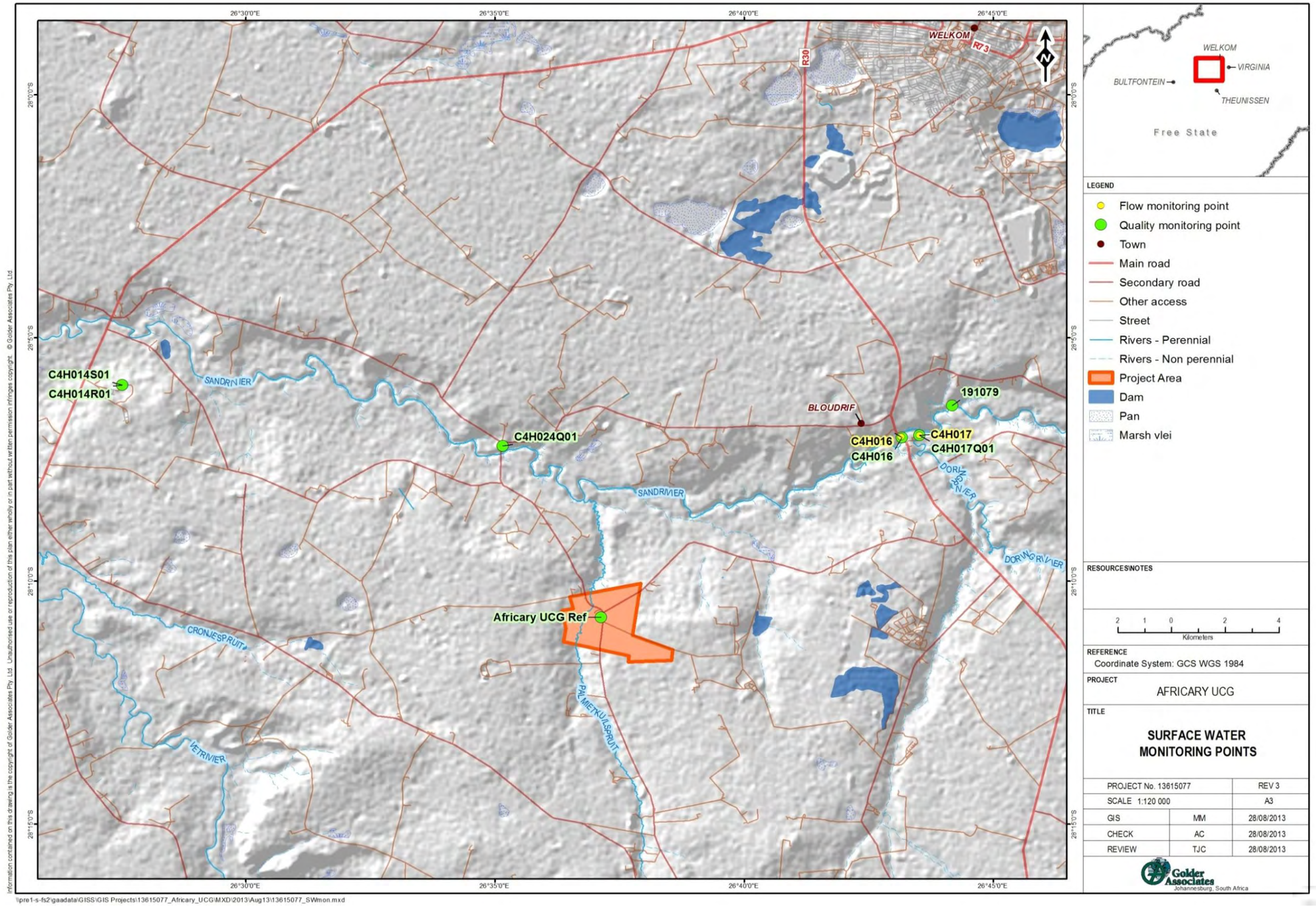


Figure 7-18: Flow and water quality monitoring stations in vicinity of Palmietkuilspruit

Table 7-18: Water Quality Monitoring stations in vicinity of Palmietkuilspruit

Station	DWA code	Station name	Distance from site (km)	US or DS from Palmietkuilspruit	No. of samples	Dates monitored
C4H016	C42_90800	Mond van Doornrivier 38 at Bloudrif on Sand River	13.13	Upstream	253	3 January 1995 to 4 July 2012
C4H017Q01	C42_90801	Sand River at Doringrivier/Bloudrif	13.74	Upstream	174	3 January 1995 to 13 June 2012
191079	C42_191079	Adamsonsvley 655 ± 2.5 km downstream of WWTW Discharge Point on Sand River	15.37	Upstream	1	16 August 2012
C4H024Q01	C42_90807	At Jakhalskop Road Bridge downstream Bloudrif on Sand River	7.50	Downstream	36	6 October 1998 to 18 January 2012
C4H014R01	C42_103046	Sand-Vet Treatment Works (Zeebrugge) - Aldam Raw W Potable Water Treatment Works	19.91	Downstream	30	8 April 1991 to 26 March 1993
C4H014S01	C42_103047	Sand-Vet Treatment Works (Zeebrugge) - Treated Water Potable Water Treatment Works	19.91	Downstream	41	1 April 1991 to 26 March 1993

Table 7-19: DWA water quality measurements in the Palmietkuilspruit area

Sample ID			191079	90801			90800			90807			103046			103047		
Station Number				C4H017Q01			C4H016			C4H024Q01			C4H014R01			C4H014S01		
Quaternary			C42K	C42K			C42L			C42L			C42L			C42L		
Date/Time sample taken			16/08/2012 10:28	1995 to 2012			1995 to 2012			1998 to 2012			1991 to 1993			1991 to 1993		
River			Sand	Doring			Sand			Sand			Sand-Vet			Sand-Vet		
Upstream/Downstream			US	US			US			DS			DS			DS		
Distance from site			15.73	13.74			13.13			7.5			19.91			19.91		
Percentile				5	50	95	5	50	95	5	50	95	5	50	95	5	50	95
Parameter	Unit	Acceptable limits*																
Electrical Conductivity, EC	mS/m	150	116	42.7	168.0	263.5	40.5	134.3	205.4	39.9	147.5	207.8	24.47	27.80	29.69	22.78	26.50	28.42
pH		4.5-10	8.57	7.70	8.24	8.63	7.57	8.22	8.93	7.86	8.19	9.21	7.61	7.82	8.27	6.41	7.60	8.21
Total Alkalinity as CaCO3	mg/l			88.3	161.7	255.8	85.3	167.7	233.1	113.1	168.5	216.9	69.4	91.6	115.1	61.9	96.4	111.0
Total Dissolved Solids, TDS	mg/l	1000		226.1	914.4	1337	245.7	866.4	1252	265.8	911.1	1102	176.9	194.0	219.2	170.0	194.0	213.2
Ammonium, NH4	mg/l	2	0.25	0.020	0.025	0.143	0.020	0.025	0.277	0.019	0.023	0.160	0.064	0.139	0.248	0.020	0.020	0.058
Chloride, Cl	mg/l	200		42.3	320.8	677	44.8	241.3	426.6	37.3	254.8	635	9.7	26.1	33.0	7.0	11.9	36.1
Fluoride, F	mg/l	1		0.180	0.302	0.481	0.189	0.330	0.500	0.253	0.330	0.393	0.271	0.280	0.379	0.302	0.350	0.438
Nitrate Nitrite as N	mg/l	10	1.25				0.020	0.369	3.403	0.020	0.086	2.022						
Sodium, Na	mg/l	200		27.6	144.5	216.0	32.0	136.7	216.3	33.8	134.1	215.7	17.2	17.6	22.6	17.1	18.0	21.2
Sulphate, SO4	mg/l	400		29.8	89.1	191.3	35.9	145.4	258.4	33.3	145.7	234.7	5.53	9.40	10.30	4.4	9.4	14.5
Calcium, Ca	mg/l	150		26.9	91.5	174.2	27.3	78.5	117.1	28.5	82.2	173.9	17.9	19.1	22.2	18.6	21.5	23.1
Magnesium, Mg	mg/l	100		11.1	46.9	90.1	10.8	39.3	62.8	10.3	40.4	80.1	6.57	8.10	8.64	5.6	7.2	8.68
Nitrogen Kjehldahl, N (Total)	mg/l						0.505	0.973	1.898	0.258	0.760	1.925						
Orthophosphate, PO4	mg/l		3.2	0.005	0.048	0.325	0.021	0.309	1.815	0.019	0.225	0.680	0.011	0.014	0.062	0.005	0.013	0.020
Phosphorus, P	mg/l			0.020	0.055	1.664	0.104	0.379	1.322	0.038	0.390	0.881	0.049	0.089	0.453	0.020	0.092	3.671
Potassium, K	mg/l	50		4.966	9.765	14.3	5.476	12.1	21.8	4.841	11.8	16.4	5.317	5.650	6.361	4.478	4.920	5.902
Silicon, Si	mg/l			0.317	2.786	8.492	0.464	2.760	6.810	0.200	1.555	6.872	1.033	1.960	4.237	1.306	2.440	4.684

*Water Quality was measured against acceptable Domestic Water Users guidelines as it is the most sensitive case (Department of Water Affairs and Forestry, 1996).

7.7.6 Flood line determination

The flood lines for the Palmietkuilspruit were determined in the following manner:

- The catchment area of the Palmietkuilspruit was delineated, based on the 1:50 000 topographical maps;
- A flood peak analysis was undertaken to determine the different recurrence interval flood peaks for the watercourses within the area using various flood estimation methods;
- The flood peaks and the survey data of the study area were used as inputs to the HEC-RAS backwater programme to determine the surface water elevations for the 1: 50 and 1:100 year floods peaks;
- The flood lines were plotted on the available mapping;
- Runoff volumes were calculated theoretically using the various flood estimation methods;
- Manning's *n* coefficients were estimated by comparing the vegetation and nature of the channel surfaces to published data (Webber, 1971).

Various flood estimation methods namely, the Rational Method using Point Precipitation (RM-PP), the Rational Method using TR102 (RM-TR_1), the Standard Design Flood method (SDF) and the Empirical Flood Estimation method or the Regional Maximum Flood method (RMF) were applied to the Palmietkuilspruit sub-catchment. The sub-catchment characteristics used in applying these methods are listed in Table 7-20.

Table 7-20: Subcatchment characteristics used in the flood estimation methods

Stream Name	Catchment	Quaternary Catchment	Area (km²)	River Length (m)	10-85 Slope (m/m)	Time of concentration (h)
Palmietkuil spruit	Entire	C42L	148.27	33 180	0.005024	7.548

The Palmietkuilspruit flood peak flows for the 1 in 50 and 1 in 100 year flood were calculated as 202.9 and 270.6 m³/s respectively. The resulting flood lines are shown in Figure 7-20.

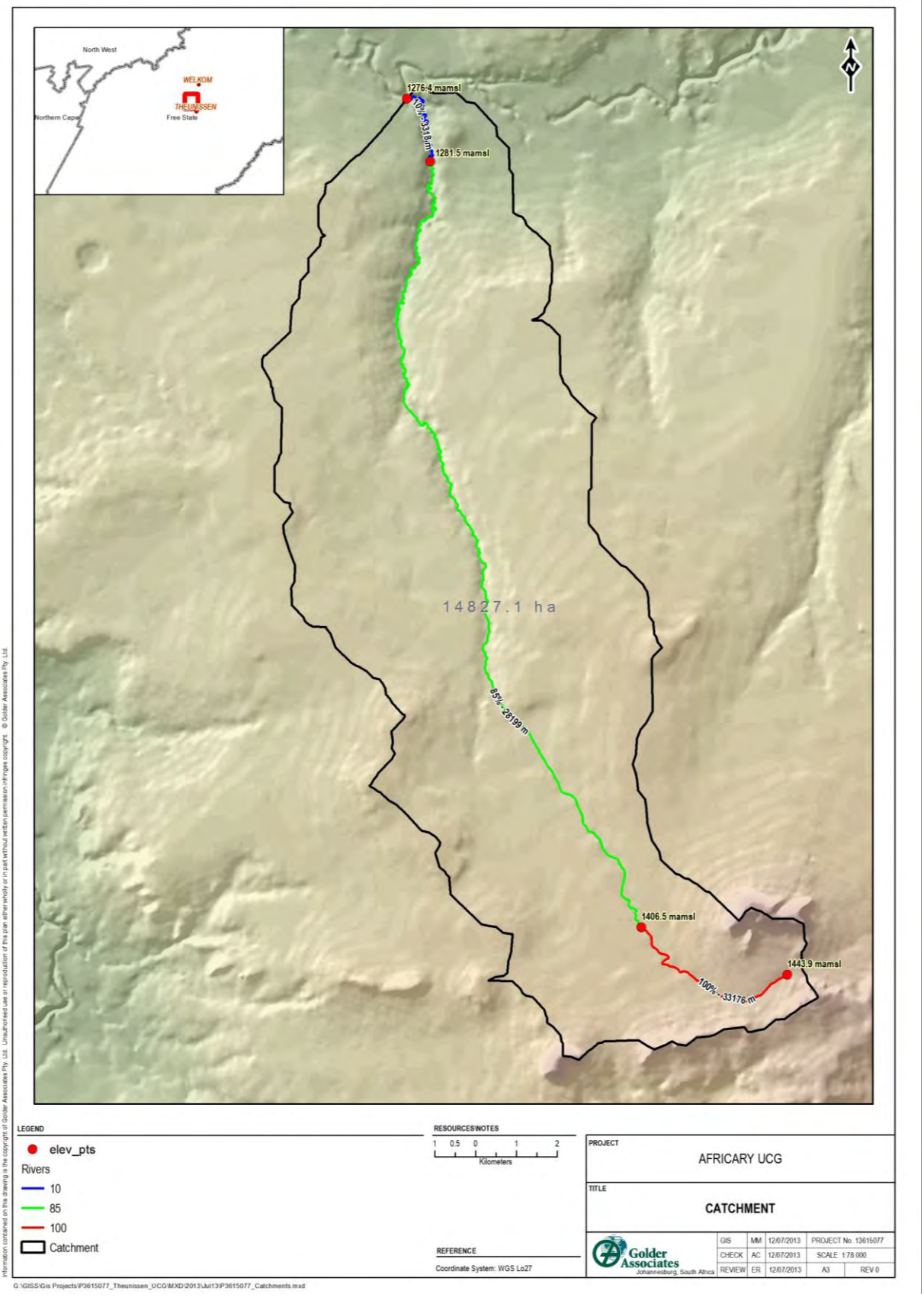


Figure 7-19: Catchment boundary of Palmietkuilspruit for floodline determination

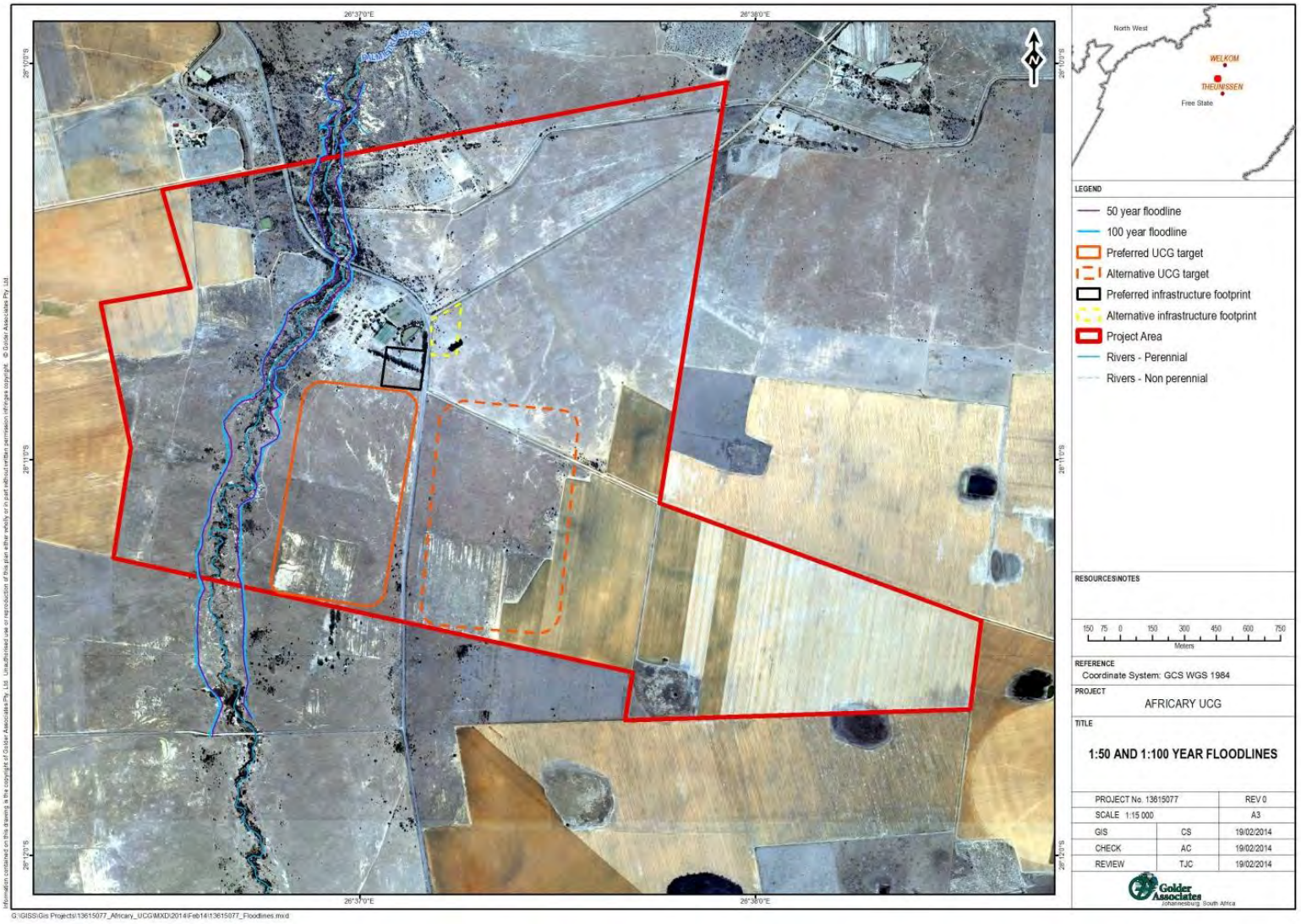


Figure 7-20: Flood lines for the Palmietkuilspruit in the project area

7.8 Groundwater

7.8.1 Regional groundwater conditions

It is known from previous groundwater studies at the nearby gold mines that two main aquifers exist in the area, namely:

- A shallow aquifer, which lies close to the surface within the weathered and fractured zone of the Karoo sediments; and
- A deep aquifer, which has developed in the fractured and faulted Ventersdorp and Witwatersrand, rocks.

Most of the ground water in the area is used for domestic and stock watering purposes. (Pretorius, H; van der Merwe , A B;, November 2012)

Boreholes drilled in the Beaufort sediments generally yield ground water of a better quality compared to those boreholes in the Ecca sediments. The ability of groundwater to leach salts from rock formations generally increases with temperature, i.e. the salinity of the groundwater increases with depth. The geothermal gradient is higher in this area than that in in the northern part of the Witwatersrand Basin (15^{o}C per km *vs*. 9^{o}C per km).

Fracture water sampled at depths of around 800m below surface was hydrothermal in origin and had significantly higher concentrations of iron, manganese, sodium, chloride, bromide and sulphate than the groundwater in the shallow aquifer. The difference in chemical composition indicates that the degree to which the Karoo groundwater in the shallow aquifer can directly mix with the fracture water is less than 10% and that some of the mixing may be due to the gold mining activities (Lin, et al., 2006). The groundwater flow direction typically follows the surface topography, which slopes very gently (1 in 200) towards the north-east.

In the Sand/Vet sub-catchment activities associated with gold mining have the largest impact on the groundwater quality. Activities related to urban areas can also result in localized or even diffuse pollution of groundwater. In the Welkom area poor management of sewage treatment works contributes to the groundwater pollution by discharging raw sewage directly in into evaporation pans (Basson, M S; Rossouw, J D;, 2003). Other sources of pollution are landfill sites, on-site sanitation (especially in informal settlements) and spills resulting from accidents or leaking underground tanks.

7.8.2 Baseline groundwater conditions at UCG target area

The groundwater conditions at the UCG target area were investigated during the impact assessment phase (Muresan, M;, February 2014). A hydrocensus study was conducted on six existing boreholes on the farms Palmietkuil, Klein Palmietkuil, Carlo, and Voorspoed (BH1, BH2, BH7, BH8, BH11 and BH13 – see Figure 7-21. Geochemical properties of the shallow aquifer were measured in the field and water samples were taken for chemical analysis. The hydrocensus data is summarised in Table 7-21 and the geochemical properties in Table 7-22.

The values measured in the field indicate the water quality to be generally good and suitable for domestic use. The salinity, expressed as EC and TDS, exceeds the *"Ideal"* guideline but is still within the *"Marginal to no health effects"* range when compared against the *South African Water Quality Guidelines (SAWQG), Volume 1: Domestic Use.* Turbidity exceeds the *"Unacceptable"* guideline value of 5 NTU's for all the boreholes, and the results are likely caused by particulate matter from the casing or borehole annulus, and should not pose a serious health risk.

The redox potential (ORP) shows that the water is slightly oxidising, and dissolved oxygen (DO) is also within acceptable limits.

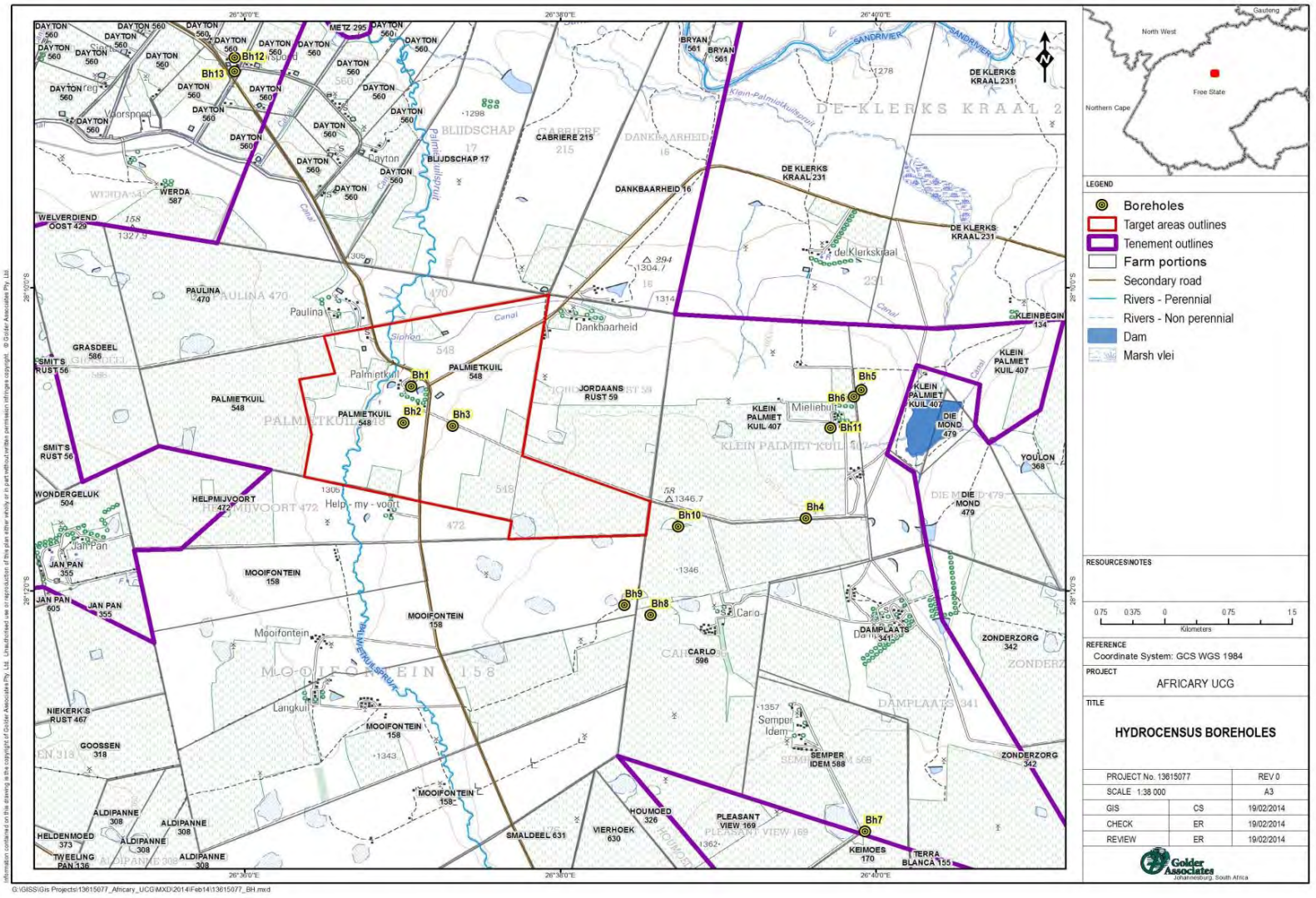


Figure 7-21: Hydrocensus boreholes in the vicinity of the project area

Table 7-21: Summary of hydrocensus data

Borehole No	Coordinates (WGS 84)		Water level (mbgl)	Owner	Farm	Water use	Reported yield (l/s)	Sample taken	Pump Equipment
Bh1	26.61765	-28.1776	8.14	Manie Engelbrecht	Palmietkuil	Domestic	1	yes	Submersible
Bh2	26.61681	-28.1816	10.24	Manie Engelbrecht	Palmietkuil	Not in use		yes	No pump
Bh3	26.62203	-28.1819	14.12	Manie Engelbrecht	Palmietkuil	Not in use		no	Broken Windmill
Bh4	26.65932	-28.192	4.22	Kobus vd Berg	Klein Palmietkuil	Not in use		no	Broken Windmill
Bh5	26.6644	-28.1787	12.30	Kobus vd Berg	Klein Palmietkuil	Not in use		no	Open hole
Bh6	26.66515	-28.1779	Blocked	Kobus vd Berg	Klein Palmietkuil	Not in use		no	Broken Windmill
Bh7	26.66553	-28.2265	Closed Hole	Dawie	Carlo	Irrigation	8.4	yes	Submersible irrigation, pumping to dam for pivots
Bh8	26.6429	-28.2027	Closed Hole	Dawie	Carlo	Irrigation	10	yes	Submersible irrigation, pumping to dam for pivots
Bh9	26.64012	-28.2016	8.05	Dawie	Carlo	Not in use		no	Broken Windmill
Bh10	26.64581	-28.193	3.04	Dawie	Carlo	Not in use		no	Broken Windmill
Bh11	26.6619	-28.1821	12.08	Kobus vd Berg	Klein Palmietkuil	Domestic	0.8	yes	Submersible
Bh12	26.59898	-28.1414	22.60	Hennie Pieterse	Voorspoed	Not in use			Open hole
BH13	26.598977	28.142951							

Table 7-22: Summary of field geochemical parameters

Borehole Id	pH	EC (µs/cm)	ORP (mV)	Turbidity (NTU)	TDS (mg/l)	DO (mg/l)	Temp (degrees C)
DWA (1996) Domestic use – (Ideal)*	**6 to 9.1**	**<700**		**<1**	**<450**		
Bh1	7.25	792	107.3	21.1	516	0.2476	20.1
Bh2	9.43	864	31.2	11.5	561	0.104	21.3
Bh7	7.83	805	140.2	18.7	429	0.466	16.1
Bh8	7.81	651	140.4	10.3	423	0.321	18.2
Bh11	7.71	643	144.8	17.7	263	0.378	18.6
Bh13	7.92	596	128.9	7.5	387	41.2	17

***Only the "*Ideal*" range guideline is shown in table**

The results of the chemical analyses are shown in Table 7-23 (macro inorganics), **Table 7-24** (trace elements) and **Table 7-25** (organics).

Table 7-23: Analytical results - inorganics

SiteName	DWAF 1996 - Domestic Use	BH1	BH2	BH7	BH8	BH11	BH13
pH	**6 - 9.1**	7.14	7.2	7.6	7.39	7.66	7.64
EC mS/m	**70.00**	99.1	121.0	85.0	84.4	84.5	79.4
TDS mg/l	**450.00**	672.0	754.0	588.0	566.0	570.0	506.0
Ca mg/l	**32.00**	83.7	102	58.8	61.4	66.7	35.9
Mg mg/l	**50.00**	19.8	25.6	22.5	24.7	22.2	11.5
Na mg/l	**100.00**	102	104	84	78	71.7	122
K mg/l	**50.00**	6.29	7.63	9.02	8.35	9.98	6.16
MALK mg/l		347.0	329.0	339.0	303.0	287.0	341.0
Cl mg/l	**100.00**	100	176	51.9	56.4	47.4	50.2
SO4 mg/l	**200.00**	65.7	85.9	46.5	56.9	74.4	52.5
Si mg/l		17.9	18	19.5	20	16.9	16.6
NO_3 mg/l		32.1	31.8	65.1	86.5	77.9	8.18
NO_3 as N mg/l	**6**	7.25	7.19	14.7	19.5	17.6	1.85
F mg/l	**1.00**	0.248	0.168	0.261	0.305	0.255	0.2
Ca Hardness mg/l $CaCO_3$		209.0	255.0	147.0	153.0	167.0	89.6
Mg Hardnes mg/l $CaCO_3$		81.5	105.0	92.7	102.0	91.4	47.4
Total Hardness		291.0	360.0	239.0	255.0	258.0	137.0
PO_4-P mg/l		1.9	BDL	BDL	BDL	BDL	BDL

***Only the "*Ideal*" range guideline is shown in the table**

Table 7-24: Analytical results - trace metals

SiteName	DWAF 1996 - Domestic Use	BH1	BH2	BH7	BH8	BH11	BH13
Fe mg/l	**0.10**	0.350	<0.050	7.830	1.360	<0.050	<0.050
Ba mg/l		0.100	0.120	0.069	0.073	0.053	0.031
Cr mg/l	**0.05**	0.070	<0.050	<0.050	<0.050	<0.050	<0.050
Ni mg/l		0.050	0.003	<0.050	<0.050	<0.050	<0.050
Sr mg/l		0.570	0.790	0.670	0.630	0.790	0.490
B mg/l		0.084	0.083	0.094	0.087	0.093	0.142
V mg/l	**0.1**	0.006	0.007	0.009	0.012	0.003	<0.001
Cu mg/l	**1**	<0.001	0.004	<0.001	<0.001	<0.001	<0.001
Zn mg/l	**3**	0.011	0.034	0.013	<0.001	<0.001	0.099

Regarding electrical conductivity/dissolved solids, all samples exceeded the "*ideal*" guideline for Domestic use, but still fell within the *"marginal to no health effects"* range. The pH values are within the "*ideal*" range (7.14 – 7.66) and the groundwater can be described as neutral. The other inorganic constituents all fall within the "ideal" guideline values with the exception of:

- Ca, Na and Cl, which exceed the "*marginal to no health effects"* range for BH1, BH2 and BH13;
- Ca, which exceeds the "*unacceptable"* range for boreholes BH1 and BH2, and the *"marginal to no health effects"* range for the rest of the boreholes;
- NO_3 as N, which exceeds the "*unacceptable"* range for boreholes BH7, BH8, and BH11, and the *"marginal to no health effects"* range for the rest of the boreholes. The high nitrate is likely caused by fertiliser application on crops and/or leakage from pit latrines or septic tanks at the homesteads.
- Fe exceeds the "ideal" range in BH1, BH7 and BH8, but still falls within the *"marginal to no health effects"* range; and
- Cr exceeds the "ideal" range in BH1but still falls within the *"marginal to no health effects"* range.

The organics analyses included more than 200 organic compounds that are common groundwater contaminants. Of these, only total petroleum hydrocarbons (TPH), Styrene and monochlorobenzene were detected at very low ranges in boreholes BH2, BH1, BH7, respectively. These contaminants are often associated with diesel, lubricants/oils and degreasers, which are all products that are commonly present in a farming environment.

Table 7-25: Organic analysis results (limited to constituents that tested above detection limit)

Analysis	Unit	1 (BH8)	2 (BH2)	3 (BH11)	4 (BH1)	5 (BH7)	6 (BH13)
Total Petroleum Hydrocarbons							
TPH C21-C30	µg/L	BDL	29	BDL	BDL	BDL	BDL
Mono Aromatic Hydrocarbons							
Styrene	µg/L	BDL	BDL	BDL	0.1	BDL	BDL
Chlorobenzenes							
Monochlorobenzene	µg/L	BDL	BDL	BDL	BDL	0.053	BDL

Groundwater is used in the project area for irrigation and domestic purposes. Water levels and yields are typical of Karoo type aquifers and can vary depending on geological features (i.e. dolerite dykes/sills) that can enhance the permeability of the sedimentary rock layers.

7.9 Terrestrial Ecology

An ecological survey was undertaken during June/July 2013 (Moffet, M;, July 2013).

7.9.1 Regional setting and characteristics

The proposed development is located in the Dry Highveld Grassland in the central plateau of South Africa. The topography is flat to undulating and incised by river valleys including the Sand River and its tributaries such as the Palmietkuilspruit and an unnamed tributary that has been dammed for irrigation purposes (Canal Dam).

The topography is gently undulating to flat and slopes from the south in a northerly direction towards the Sand River. The altitude varies from 1321 metres above mean sea level (mamsl) at the Africary site, to 1295 mamsl along the gravel road (water pipeline Option 1) to approximately 1350 mamsl near Beatrix No. 4 shaft over a distance of approximately 11 km. The Sand River is located north of the project area (See Figure 7-18). The Palmietkuilspruit, a seasonally flowing tributary of the Sand River, runs near the western boundary of the preferred power plant site (Figure 7-22).

Figure 7-22: View of Palmietkuilspruit, with farmhouse in the background

The project area is also characterised by several small and large farm dams. There is a small farm dam behind an erosion protection berm on the alternative power plant site (Figure 7-23). Sedges including *Cyperus* sp. and *Scirpus corymbosus* were seen growing around the edges of the dams. Waterfowl including Yellow-billed Duck and Spurwing Goose were observed near the dam on the alternative power plant site. This dam does not qualify as a wetland in terms of the Department of Water Affairs' criteria.

Figure 7-23: Small farm dam on alternative power plant site

The power line and water pipeline route crosses an unnamed and smaller tributary of the Sand River and goes past the 'Canal Dam' that is part of the Sand/Vet River Irrigation Scheme. This scheme consists of a number of concrete canals that transport water which is used for the intensive irrigation of crops by local farmers (See Figure 7-24 and Figure 7-25).

Figure 7-24: Roads and Sand-Vet Irrigation Infrastructure

Figure 7-25: Sand-Vet Irrigation Scheme concrete canals traverse the project area

7.9.2 Vegetation

The project area is located within the Grassland Biome of South Africa (Figure 7-26) (Rutherford & Westfall, 1994). This Grassland Biome is an important agricultural region, especially for the intensive production of crops such as maize and wheat (Department of Agriculture, Forestry and Fisheries: Abstract of agricultural statistics, 2010). It is also important for extensive stock farming, mainly for dairy, beef and wool production. However, the intensive crop production and livestock grazing pressure have resulted in the destruction or degradation of large portions of pristine vegetation in the biome.

The vegetation structure as well as the environmental factors, the summer rainfall and the minimum temperature in winter help to define the extent of the biome (Mucina & Rutherford 2006). Therefore, the Grassland biome is dominated by grasses with an absence of a shrub layer and karoo bushes because of the low temperatures reached during the winter months (Mucina & Rutherford 2006). This biome is located within the summer rainfall area. The mean annual rainfall varies between 400 and 2 500 mm (Rutherford & Westfall 1994; Mucina & Rutherford 2006). The minimum temperature for the coldest months is consistently below 1°C.

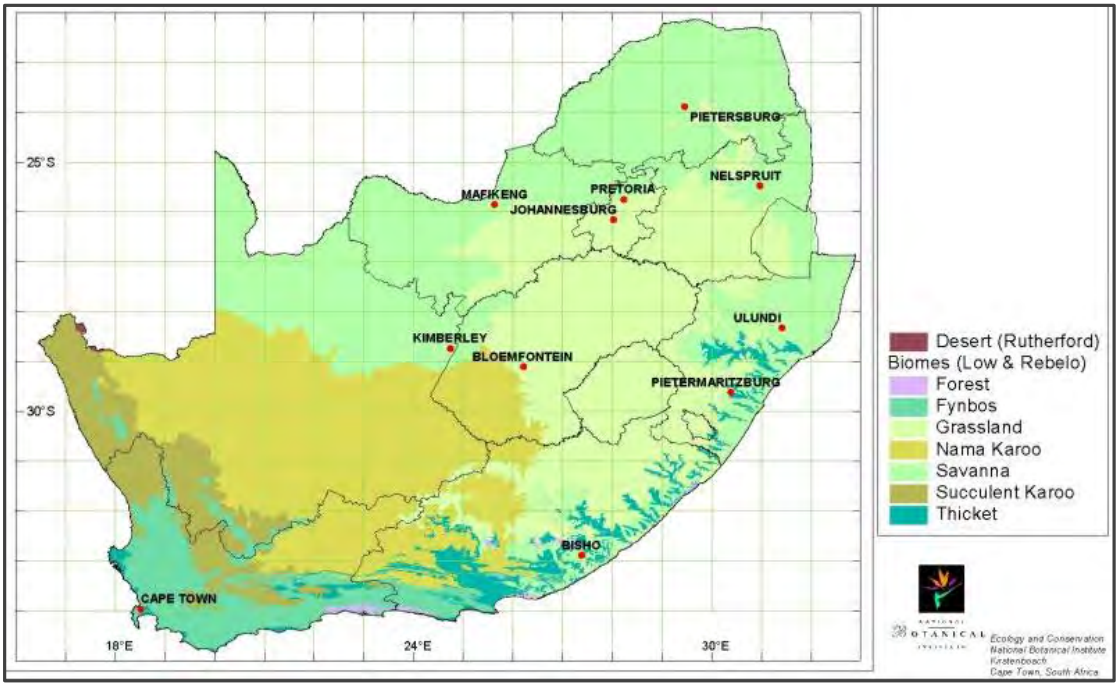


Figure 7-26: Biomes of South Africa (NBI, 1997)

The vegetation type in the area adjacent to the Palmietkuil stream is referred to as Highveld Alluvial Vegetation (AZa 5 Alluvial Vegetation) (Mucina and Rutherford, 2006) as indicated in Figure 7-27. Within the study area, this vegetation occurs along the Sand River, and is mostly confined to floodplains (Mucina & Rutherford 2006).

The landscape has a flat topography which supports riparian thickets which are dominated by trees such as *Acacia karroo* and *Salix mucronata* and shrubs such as *Diospyros lycioides, Searsia pyroides* and *Ziziphus mucronata.* The undergrowth is dominated by various grasses and numerous alien weeds which are subjected to frequent impacts such as annual floods, fires and grazing (Mucina & Rutherford 2006). This vegetation unit is less threatened as 10% of the targeted 31% of the area is conserved. Approximately a quarter of the original extent has been transformed for cultivation and the building of dams and weirs. Although this area is the least threatened, the occurrence of alien species along the rivers is high because of the high nutrient status as well as the ample water supply in the soils. Overgrazing is becoming a problem in certain areas of this vegetation unit (Mucina & Rutherford 2006).

The vegetation types in the vicinity of the project area, as mapped by van Aardt, are shown in Figure 7-27 (van Aardt, 2010)

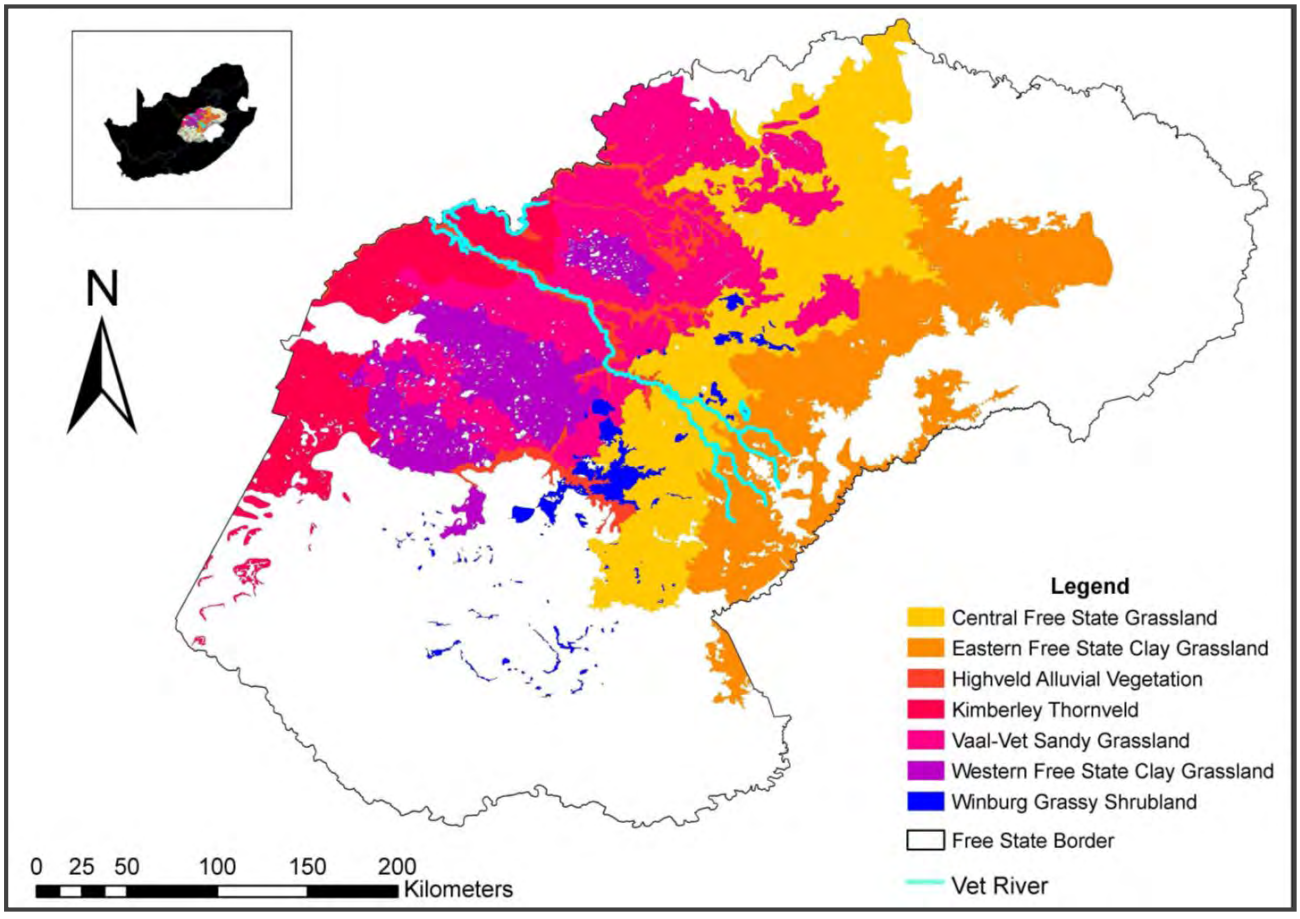


Figure 7-27: Map of the different vegetation types near the study area (Van Aardt, 2010)

Further away from the Palmietkuil stream, the alluvial vegetation type merges into a grassland vegetation type that is known as the Vaal-Vet Sandy Grassland Vegetation (Unit Gh 10), which is embedded within the Highveld Alluvial Vegetation (Unit AZa 5) (Mucina and Rutherford, 2006) (See Figure 7-28). The Vaal-Vet Sandy Grassland Vegetation Unit is a plains-dominated landscape with vegetation dominated by low-tussock grasses with karroid shrubs and succulents.

More than 63% of the Vaal-Vet Sandy Grassland has been irreversibly transformed for cultivation and the rest is under strong grazing pressure from cattle and sheep. Only 833 982 ha remains of the original 227 431 637 ha and the remaining extent of this vegetation type has been listed as Endangered (SANBI, 2009). Less

than 0.3% of the original ecosystem is protected in the Bloemhof Dam, Schoonspruit, Sandveld, Faan Meintjies, Wolwespruit and Soetdoring Nature Reserves.

The plant species observed in the preferred and alternative infrastructure areas are similar in nature and consist mainly of grasses and geophytes with few forbs and trees. Small remnants of riparian thicket vegetation occur on both sites.

The soil in the power plant infrastructure area is predominantly clayey and supports a number of small geophytes. Species observed include *Androcymbium roseum* subsp. *albiflorum*, *Massonia jasminiflora*, *Hypoxis filiformis* and *H. hemerocallidea*. These bulbous plants grow in response to autumn rains which fall in March and April. They flower mostly while they are in leaf at the end of the autumn and in the early winter (mid April to mid June). *Hypoxis hemerocallidea* is listed as Declining in the Red List of South African plants (Raimondo, 2009) due to its extensive commercial exploitation for medicinal use. It was growing in the road reserve.

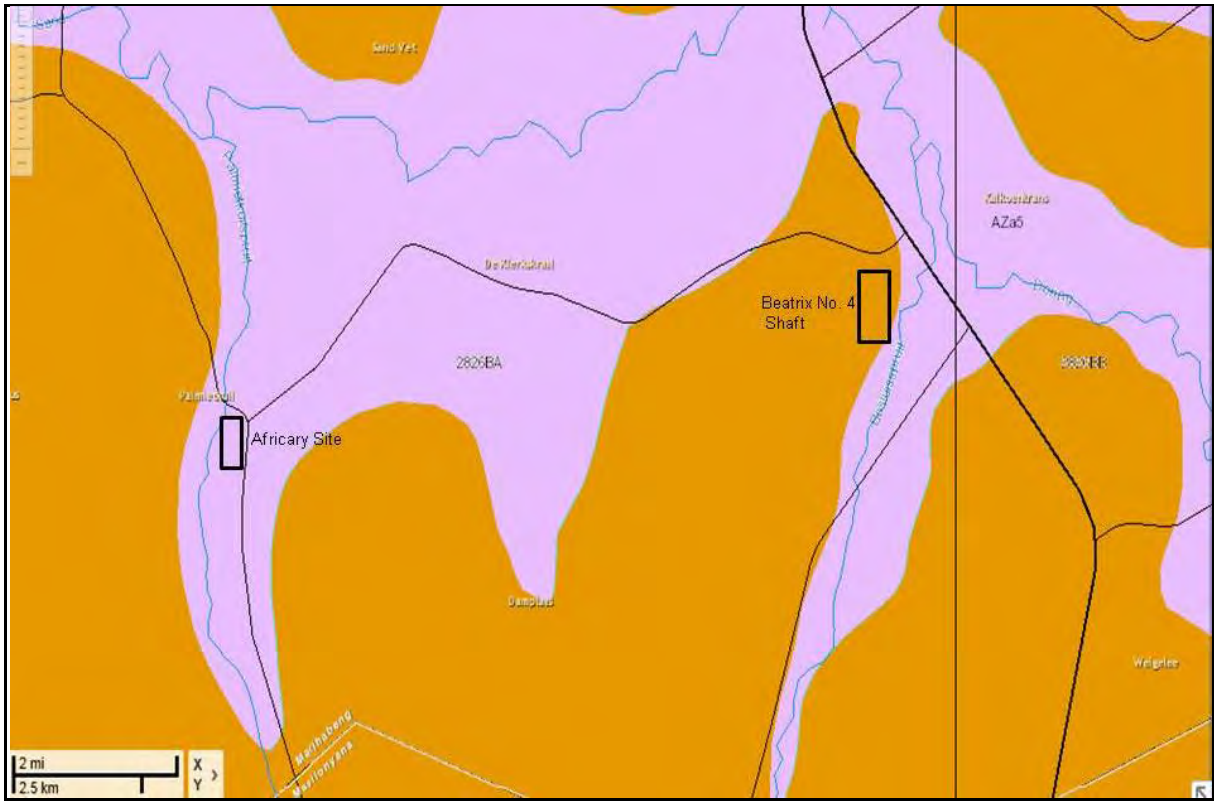


Figure 7-28: Dominant vegetation units (AZa 5): Highveld Alluvial Vegetation (pink) and (Gh 10): Vaal-Vet Sandy Grassland (orange)

Other plant species observed on the power plant site include the dominant grass *Themeda triandra* (Red Grass) and *Anthephora pubescens* (Wool Grass), *Aristida congesta* (Tassel bristlegrass), *A. diffusa* (Iron Grass), *Elionurus muticus, Eragrostis lehmanniana* (Lehmann's Love Grass, which commonly occurs on disturbed areas such as overgrazed veld and old cultivated lands), *E. superba* (Saw-tooth Love Grass), *E. plana*, *E. curvula* (Weeping Love Grass), *E. chloromelas* (Curly Love Grass), *E. obtusa* (Dew Grass), *Hyparrhenia hirta* (Thatch Grass), *Cynodon dactylon* (Couch Grass), *Digitaria argyrograpta* (Silver Finger Grass) and *D. eriantha* (Common Finger Grass).

Small trees, shrubs and bushes noted include the dominant *Acacia karroo* (Sweet thorn), *Searsia pyroides* (Common wild currant), *Lycium hirsutum* (River honey thorn), *Maytenus polycantha* (Kraal spike thorn), *Felicia muricata* subsp. *muricata*, *F. filifolia* subsp. *filifolia*, *Protoasparagus laricinus, P. suaveolens* and *Chrysocoma ciliata*. Forbs noted on site included *Hermannia depressa*, *Helichrysum rugulosum*, *Stoebe vulgaris* and *Dicoma macrocephala*. The vegetation around the small farm dams consists mainly of sedges including *Cyperus* sp. and *Scirpus corymbosus*.

The riparian thickets adjacent to Palmietkuilspruit consist of alluvial vegetation fringing the spruit and seasonally flooded grasslands that gradually merge with the Vaal-Vet Sandy Grassland vegetation. The riparian thickets along the banks are dominated by dense stands of *Acacia karroo* (Sweet Thorn). Shrubs in the undergrowth include *Protoasparagus laricinus* and *Searsia pyroides* (Common Wild Currant). Scattered small trees, most of which are armed with spines, include *Ehretia alba* (Puzzle bush), *Lycium hirsutum* (River honey thorn), *Ziziphus mucronata* (Buffalo thorn) and *Maytenus polycantha* (Kraal spike thorn). *Clematis brachiata* (Travellers Joy) was also seen growing over the thicket vegetation. Reed beds consisting mainly of *Typha capensis* (bulrush) occur adjacent to the watercourse.

The four electrical powerline and water pipeline route options are located within the Highveld Alluvial Vegetation Unit which merges with the Vaal-Vet sandy Grassland Unit. The unnamed tributary of the Sand River runs roughly through the middle of the four route options in a north-south direction, dividing the route options into western and eastern sections.

The vegetation on either side of the tributary over a distance of a few hundred metres consists of dense, riverine thicket similar to that observed along the Palmietkuilspruit, but it has been overgrazed and the grass and shrub cover is sparser. This tributary was not flowing at the time of the survey and species typical of permanent water bodies such as reeds and sedges were not observed. Several small, spinescent trees and shrubs such as *Acacia karroo, Searsia pyroides, Lycium hirsutium, Ehretia rigida, Grewia flava, Ziziphus mucronata* and *Protoasparagus laricinus* were observed growing along and around the unnamed tributary. The dominant grass in this area is *Themeda triandra* (Red Grass).

The vegetation along the pipeline and power line route options to the east of the unnamed Sand River tributary has been transformed almost entirely by the establishment of maize fields and mining infrastructure and consists predominantly of pioneer and weedy species characteristic of disturbed areas. Species noted include Couch Grass (*Cynodon dactylon*), Steekgras (*Aristida* sp.), small *Senecio* sp. tumble weed, and Chinese tamarisk closer to the Beatrix No. 4 mine infrastructure.

The vegetation to the west of the unnamed tributary and closer to the power plant site consists mainly of grasses and small shrubs and trees with few forbs. Much of this area is currently used for grazing and the dominant grass noted along the route was *Themeda triandra* (Red Grass) and the dominant shrub was *Protoasparagus laricinus*. Small karroid bushes including *Felicia muricata, Helichrysum* sp., *Pentzia* sp, and Asclepias sp. were growing in this predominantly grassland area. The vegetation to the south of the pipeline and power line route options has been transformed by the establishment of cultivated fields, mainly for maize.

Exotic and invasive plant species are scattered throughout the project area. Alien trees near the power plant site include Syringa (**Melia azerach*), *Eucalyptus* sp. and **Opuntia* sp. growing next to *Hypoxis hemerocallidea* in the road reserve; **Agave* species were noted in riverine thicket as well as **Solanum sisymbrifolium* (nightshade), **Ligustrum* sp. (Privet), **Cirsium vulgaris* (Scottish thistle) and several naturalised alien forbs including **Verbena bonariensis, *V. brasiliensis, *Tagetes minuta* (Khaki weed), **Homeria pallida* (Yellow tulip/tulp) and **Bidens pilosa* (blackjack).

The Chinese tamarisk (**Tamarix chinensis*), which is a Category 1 weed (CARA, 2002) was seen in large numbers around the Beatrix No. 4 shaft tailings infrastructure area. This tree competes with and replaces indigenous plant species. Dense stands could significantly reduce stream flow and groundwater reserves.

7.9.3 Fauna

7.9.3.1 Avifauna

According to the Southern African Bird Atlas Project (SABAP –Harrison *et al.* 1997) 183 bird species were recorded in the quarter-degree square covering the proposed development area (2826 BA Bloudrif, Free State Province). The complete list, as well as the list of 104 species observed in the project area during the ecological survey undertaken in June/July 2013, appears in the specialist report (Moffet, M;, July 2013). Four additional species, namely Spotted Thick-knee (*Burhinus capensis*), Common Scimitarbill (*Rhinopomastus cyanomelas*), Karoo Scrub Robin (*Erythropygia coryphoeus*) and Pied Kingfisher (*Ceryle rudis*) were recorded during the ecological survey. The SABAP lists ten Red Data species for the quarter-degree square, none of which were observed in the project area.

The Palmietkuil stream provides habitat for waterfowl and shorebirds and species such as the South African Shelduck, Cape Shoveller and Southern Pochard, as well as various herons, egrets, ibises, cormorants and the African Darter.

A conspicuous large bird observed throughout the project area is the Northern Black Korhaan (*Afrotis afraoides*), a common endemic resident. This species was observed in pairs and is assumed to be breeding in the project area. Other species observed in the thicket and grassland area included and Francolins, Guinea fowl, Thick-knees and Plovers.

7.9.3.2 Mammalia

Data on the distribution of mammals using Smithers' Mammals of Southern Africa (Apps, 2000) indicate that up to 66 mammal species, of which 13 are listed in the Red Data book, may occur in the greater project area.

Fauna that are likely to occur naturally in the project are conserved in the nearby Willem Pretorius Nature Reserve. Larger mammals that occur in this reserve include White Rhino, Buffalo, Giraffe, Eland, Black Wildebeest (one of the largest populations in South Africa); Red Hartebeest, Common Reedbuck and Burchell's Zebra. As the project area has been transformed by agricultural activities, it is highly unlikely that any of these species would occur in the area, but there are several game farms in the area where Springbok, Wildebeest, Blesbok and Ostrich, amongst other game species, were noted.

The presence of the mammals listed in Table 7-26 was confirmed during the ecological survey undertaken in June/July 2013. No Red Data species were observed.

Table 7-26: Mammalian species known to occur in the region of the project area

Scientific Name	Common Name
Xerus inauris	Ground squirrel (visual sighting)
Hystrix africaeaustralis	Porcupine (discussions with local farmer)
Potamochoerus porcus	Bushpig (discussions with local farmer)
Sylvicapra grimmia	Common Duiker (visual sighting)
Orycteropus afer	Aardvark (large holes in termite mounds)
Raphicerus campestris	Steenbok (visual sighting)
Cryptomys hottentotus	Common mole rat (burrow mounds noted throughout the area)
Galerella sanguinea	Slender Mongoose (droppings)
Suricata suricatta	Suricate (visual sighting)
Lepus saxatilis	Scrub hare (visual sighting)
Cynictis penicillata	Yellow mongoose (visual sighting)

The relatively low mammal species diversity recorded during the survey is attributed to direct and indirect disturbances resulting from anthropogenic activities, as well as historic land uses such as agriculture and localised hunting.

7.9.3.3 Reptiles

Alexander and Marais (2007) indicated that more than 23 snake species may occur in the study area with the Striped Harlequin Snake being listed as Rare in the South African Red Data book and as Near Threatened under the IUCN rating.

Other reptilian species that may occur in the study area include Agamas, Chameleons, Monitors, Lacertids (Skinks), Cordylids (Crag, Flat and Plated Lizards), Geckos, Terrapins such as the Marsh Terrapin (*Pelomedusa subrufa*) and Tortoises including the Natal Hinged Tortoise, a Near Threatened species.

No reptiles were observed during the ecological survey.

7.9.4 Amphibia

The Palmietkuilspruit and the small farm dams provide suitable habitat for several amphibian species, but none of the 12 species listed by Du Preez and Carruthers (2009) as amphibians that may occur in the project area were observed during the survey. This is associated with seasonality and frogs aestivating during winter.

Of the amphibians listed as potentially occurring in the study area, only the Giant Bullfrog (*Pyxicephalus adspersus*) is listed as Near Threatened by the IUCN (2012) and categorised as Protected on the NEM:BA TOPS List (2007). The Giant Bullfrog habitat includes seasonal, shallow, grassy pans, vleis and other rain-filled depressions in open flat areas of grassland or savanna and, at the limits of its distribution, in Nama Karoo and thicket. For much of the year, this species remains buried up to 1m underground (Du Preez and Carruthers, 2009). The probability of this species being found in the project area is rated as low to moderate due to the disturbed nature of the area.

7.9.5 Fish

Fish species that may occur in the Palmietkuilspruit or in the farm dams include the introduced Carp (**Cyprinus carpio*), Mudfish (*Labeo capensis*), Largemouth Yellowfish (*Labeobarbus kimberleyensi*), Smallmouth Yellowfish (*Labeobarbus aeneus*) and Sharptooth Barbel (*Clarias gariepinus*) (Impson, et. al, 2008).

The Orange-Vaal Smallmouth Yellowfish is endemic to the Orange-Vaal River System but has several thriving alien populations due to Inter-Basin Water Transfer Schemes as well as accidental and intentional introduction for angling purposes.

The Orange-Vaal Largemouth Yellowfish is also endemic to the Orange-Vaal River system, but is generally found only in the larger tributaries and dams below 1500m. This species is listed as Near Threatened, because of flow modifications and impaired water quality in parts of its distribution range (Impson, et al, 2008).

7.9.6 Alternatives and ecological considerations

The preferred power plant site Figure 5-1 is located approximately 450m to the east of the Palmietkuilspruit. It has been extensively disturbed by the establishment of a farmhouse, houses for farm workers, water reservoirs, wind breaks consisting of alien trees (*Eucalyptus* sp.) and a small farm dam. The grassland vegetation has been heavily overgrazed and vegetation cover is poor. Remnants of riparian thickets in the form of small *Acacia karroo, Ziziphus mucronata* and *Searsia lancea* trees and dense stands of low *Protoasparagus laricinus* shrubs still exist. Yellow-billed Duck (*Anas undulata*) and three Blackwinged Stilts (*Himantopus himantopus*) were observed around the farm dam.

The alternative site on the other (eastern) side of the tarred feeder road is also heavily grazed and is traversed by small road tracks. The floral diversity is relatively low, but several small geophytic species were observed in the area as discussed in section 7.9.2. Yellow-billed duck, Spurwing Goose and Pied Wagtail were observed at the small farm dam behind an erosion protection berm on the periphery of the site. Small canals have been dug in the grassland area to direct the flow of storm water to this dam.

Although the preferred site is located closer to the Palmietkuilspruit (a sensitive area) the alternative site is less disturbed from an ecological perspective.

The preferred and alternative UCG target areas are both overgrazed. There is a maize field on a small part of the alternative target area, but apart from that the two areas as delineated in Figure 5-1 have similar (low) ecological value. The preferred target area may be viewed as more sensitive because it extends to within about 100 metres of the Palmietkuilspruit, but the only activities undertaken on the target area will be the drilling of the injection and production wells and it would be relatively easy to avoid significant impacts on the Palmietkuilspruit.

The ecological specialist's report (Moffet, M;, July 2013) contains detailed descriptions of the ecological conditions along the four alternative power line and pipeline routes shown in Figure 5-5. This information is summarised in Table 7-27.

Table 7-27: Evaluation of power line and water pipeline route alternatives

Route Options	Route 1	Route 2	Route 3	Route 4
Important Vegetation Association	Route located within Highveld Alluvial Vegetation Unit and traversing farmers' fields adjacent to road. Vegetation within road reserve relatively dense. Fields adjacent to road reserve severely overgrazed. Several small geophytes observed in road reserve closer to Palmietkuilspruit.	Similar cover of dense Highveld Alluvial Vegetation Unit within road reserve section as Route 1 Option. Remainder of route from unnamed tributary crossing towards Beatrix No. 4 Shaft is located within highly transformed (maize and mining activities) Vaal-Vet Sandy Grassland unit.	Eastern section of route located adjacent to mining infrastructure (disturbed vegetation) and crosses maize fields (transformed vegetation) before crossing unnamed tributary of Sand and following heavily grazed Vaal-Vet Sandy Grassland unit bordering maize fields.	Western section of route runs adjacent to farm boundary demarcated by wire fence and vehicle tracks in remnants of Highveld Alluvial Vegetation Unit.
Extent of alien plant cover	*Opuntia* species in road reserve near Africary Plant.	*Opuntia* species in road reserve near Africary Plant.	*Opuntia* species throughout grassland area. *Eucalyptus* trees.	*Opuntia* species in road reserve near Africary Plant and throughout grassland area. *Eucalyptus* trees.
Current land use condition	Relatively undisturbed corridor located next to gravel road characterised by elevated dust and noise levels. Eastern section of route avoids mine infrastructure and traverses farmers' fields alongside existing gravel road.	Route traverses land that is dominated by mining and agriculture before following same route as Option 1.	Eastern section of this route Option runs through and parallel to maize fields of Vaal-Vet Sandy Grassland before running adjacent to mining infrastructure. Western section of this route runs through area where Highveld Alluvial Vegetation Unit merges into the Vaal-Vet Sandy Grassland Unit.	Western section of route traverses overgrazed and transformed Highveld Alluvial Vegetation Unit and a short section of previously cultivated maize fields.
Length of route	16.7km	14.6km	13.3km	11km
Rating	Preferred option owing to location alongside existing road.	Preferred option owing to location alongside existing road.	Least preferred option	Least preferred option

All four routes cross the unnamed tributary of the Sand River which is regarded as a sensitive area.

Routes 3 and 4 are the shortest routes, but they run through grassland which, although degraded by overgrazing and maize cultivation, has not been entirely transformed. This grassland area provides suitable habitat to the Northern Black Korhaan, a common endemic resident. This species was observed in pairs and was assumed to be breeding in the area.

Other faunal species observed in the thicket and grassland area of routes 3 and 4 include small mammals such as rabbits, small buck and francolin, guinea fowl, thick-knee and plover. The route 3 and 4 options would cause a greater disturbance to fauna such as the larger bird species and small mammals living in these relatively remote areas, when compared to the route 1 and 2 options.

Routes 1 and 2 traverse farmers' fields alongside an existing gravel road through an already disturbed area. The road reserve has a well-established vegetation cover consisting of a variety of commonly occurring small trees and shrubs and it is not vegetated by weedy species. Route 2 is shorter than Route 1 and the last section of route 2 runs through an area that has been completely transformed by mining and agricultural activities. The ecological impact of the power line and pipeline in this section would be negligible.

Based on ecological considerations only, the route 2 option is preferable as it is shorter than the route 1 option.

7.10 Socio-economic Environment

The project is located in the savannah grasslands of the Free State in the central region of South Africa that have been largely converted to agricultural cultivated fields and grazing areas. Nearby towns include Welkom, Virginia, Theunissen and Bultfontein. Several national roads exist in the area with the R30 passing close by the proposed site and a tar road passing through the site.

7.10.1 Administrative Setting

The project area is located within the Lejweleputswa District Municipality that covers an area of 31 686km^2 and in the Matjhabeng Local Municipality. The spatial planning for Lejweleputswa indicates that the district has an area of 3 190 855 ha, which constitutes about 26.4% of the total provincial land area of approximately 12 969 028ha.

The Masilonyana Local Municipality comprises the towns of Winburg, Theunissen, Brandfort, Verkeerdevlei and Soutpan. There are no major urban centres and it is about 45 kilometres towards Bloemfontein and approximately 58 kilometres from Theunissen to Welkom. The municipality benefits from the N1 toll gate as well as the N1 road that crosses through the area. It is fundamentally a rural area with no major urban centres. It is dependent on agricultural activities such as crop and livestock production. There are also significant mining activities in the area. The main water source in the area is the Erfenis Dam. The Soetdoring Nature Reserve in Soutpan is an important tourist attraction.

7.10.2 Economic Activities

The Middle Vaal WMA contributes approximately 4% of the South African GDP, which was reported as 384.31 billion US dollars (about 3 843 billion Rand) in 2012. It is expected that economic activity in the region will remain relatively static in the medium to long term. Although mining is an important contributor to the economy of the region, mining is expected to decline and the agricultural sector is expected to continue to play an important role in the economy of this WMA.

The Lejweleputswa District Municipality is a major contributor to the Free State Geographic Product (GGP) and is also regarded as an important agricultural area. The District is predominantly known as the Free State

Goldfields, which forms a part of the larger Witwatersrand basin. The economy of the region is dominated by the gold mining industry and agricultural sectors, in particular maize production.

The mining industry contributes 91% of the GGP of the Free State with approximately 98% of mining taking place in Matjhabeng and Masilonyana Local Municipalities while approximately 65% of agricultural output in the District comes from the Tswelopele and Nala Local Municipalities (Lejweleputswa District Municipality Growth and Development Strategy, 2007). Construction and trade together with agriculture contributes about 30% of the GGP of the region. Nearly 85% of the manufacturing output is located in Matjhabeng.

The impact of the mining sector is felt mainly in the densely populated urban areas while the main impact of the agricultural sector occurs in the surrounding rural areas. At a national level both these sectors are recording negative growth rates and this trend is repeating itself at a regional level. As the economies of the smaller towns are based on businesses supporting agriculture, the business climate of the smaller towns is showing negative trends. The industrial base of the region is mainly centred on the mining and agricultural sectors with very little new industrial development. One of the challenges for the region is to develop a diversified industrial and commercial base.

The economy of the Masilonyana and Matjhabeng Local Municipalities relies mainly on agriculture, stock and crop farming, gold and diamond mining and steel and peanut processing factories. Most businesses, service providers and light industries in the towns are centred on supporting these agricultural mining and manufacturing activities.

Tourism in the area is limited, as the region is not well endowed with natural attractions. There is however a potential to develop tourism with regard to specific areas such as eco-tourism, game farming, mining and cultural tourism and major sporting activities. The tourism infrastructure of the region is underdeveloped and requires upgrading. The remote rural areas, such as Boshof, Brandfort and Hertzogville offer opportunities for eco-tourism and farming.

7.10.3 Population Demographics

Table 7-28 summarises the demographic data for the Local Municipalities that form part of the Lejweleputswa District Municipality (Lejweleputswa IDP, 2011/2012). It is seen that in 2007, the District population was approximately 639 651 people, which represents a negative growth rate from an estimated 657 013 people in 2001. Population composition by gender was 335 363 (51%) female and 321 648 (49%) male. Only about 220 669 (34%) of the population within the District fell within the age group 15 to 64 years.

The information in Table 7-28 indicates that there were 17 064 households and 80 094 people in the Local Municipality. There are no major centres within the local municipal area and the closest cities are Bloemfontein, Welkom and Kroonstad.

Table 7-28: Demographic data for Lejweleputswa District Municipality

Municipal Code	Municipality	Persons		Households	
		Census 2001	Census 2007	Census 2001	Census 2007
FS 181	Masilonyana (Theunissen)	64 409	80 094	17 064	27 245
FS 182	Tokologo	32 455	21 323	8 847	7 477
FS 183	Tswelopele	53 714	40 617	12 430	12 623
FS 184	Matjhabeng	408 170	405 031	120 289	131 622
FS185	Nala	98 264	92 586	25 839	23 424
DC 18	**Lejweleputswa**	**657 012**	**639 651**	**184 469**	**202 391**

Source: Lejweleputswa IDP, 2011/2012

7.10.4 Employment Levels

Table 7-29 summarises the formal and informal employment profile for the Lejweleputswa District Municipality in 1996 and in 2004. From this table it is seen that formal employment declined significantly while informal employment remained similar.

Table 7-29: Employment Profile for Lejweleputswa District Municipality in 1996 and 2004

Lejweleputswa District	Formal Employment				Informal Employment			
	1996		2004		1996		2004	
	Number	%	Number	%	Number	%	Number	%
	229 954	36.7	164 390	28.1	11 359	20.7	20503	20.0

Source: Lejweleputswa IDP, 2011/2012

There is a high level of illiteracy in the region, especially in the rural areas and efforts to address this problem are hampered by a lack of facilities and unavailable resources. There is a general lack of technical and agricultural training facilities throughout the region. Vista is the only university in the region and although there are satellite campuses of other institutions in Welkom, they are not always accessible to remote urban and rural areas.

In 1996, the unemployment level in the District was 27.2% of the population (82 654 people) and in 2004 the unemployment rate had increased to 38.8% (156 568 people) (Lejweleputswa IDP, 2011/2012).

7.11 Cultural and Heritage Resources

A phase I heritage impact assessment (HIA) study, as required in terms of Section 38 of the National Heritage Resources Act (Act 25 of 1999), was undertaken on the area of the farm Palmietkuil 548 where Africary is considering the establishment of an underground coal gasification (UCG) project and a power generation plant and along the potential routes for a power distribution line and a water pipeline (Pistorius, July 2013).

7.11.1 Methodology

The study encompassed a survey of available literature, followed by a field survey and interviewing people living in the area. Databases kept and maintained at institutions such as the Provincial Heritage Resources Agency (PHRA), the Archaeological Data Recording Centre at the National Flagship Institute (Museum Africa) in Pretoria and SAHRA's national archive (SAHRIS) were consulted to determine whether any heritage resources of significance have been identified during earlier heritage surveys in or near the project area.

The project area was also studied by means of maps (2826BC Theunissen 1:50 000 topographical and 2826 Winburg 1: 250 000 maps and Google Earth imagery).

The field survey of the power plant area was conducted on foot. The preferred route for the electrical power line and water pipeline surveyed with a vehicle, but potentially sensitive spots along the route were surveyed on foot. The route was recorded on a GPS instrument.

7.11.2 Historical background

Although there are many Stone Age sites in South Africa, none have been reported in the wider vicinity of the project area, which might be due partly to a lack of archaeological surveys done in this part of the Free State Province.

The earliest Iron Age settlers moved into the area known today as the Free State Province from the 17th century onwards. They were Sotho-speaking groups such as the Fokeng, Kwena, Kgatla and Kubung, who entered the region from the north, the south, the east and the west. They built stone walled settlements that were scattered along the lower slopes of mountains and along the ridges where there was an abundance of stone for building material. These Late Iron Age (LIA) farmers lived in relatively large communities and kept growing numbers of large and small livestock.

The closest stone walled sites occur on Doringberg and Beckersberg within the Willem Pretorius Nature Reserve, which is located about 60 km the east-south-east of the project area.

The founding of Theunissen and its history goes hand in hand with the development of the railway system in the Orange Free State. When gold was discovered in the Witwatersrand, railways to the new gold fields were

a necessity. The town Theunissen had its origins in a small settlement known as Smaldeel, which was the junction where the main line from Bloemfontein and the line from Winburg, Clocolan, Ficksburg and Ladybrand met. The residents of the Smaldeel station and the farmers from the region applied for the establishment of a township, a process that was initially opposed and finally approved by the Free State Legislative Council in August 1907.

Theunissen was named for Commandant Helgaard Theunissen, the leader of the local commando during the Anglo Boer War.

Figure 7-29: SAR Class 16DA 850 plinthed in Theunissen, 29 May 2005

7.11.3 Types and ranges of heritage resources

In terms of the types and ranges of heritage resources listed in section 3 of the National Heritage Resources Act 1999 (Act No 25 of 1999), the Phase I HIA study for the proposed UCG Project found structures with historical significance and graveyards. These heritage resources were geo-referenced and mapped (See Figure 7-30, Figure 7-31 and Table 7-30). No pre-historical remains were recorded in the Project Area, nor did this study provide for a paleontological study.

Table 7-30: Cultural and heritage resources in vicinity of project area

Historical structures	Distance from perimeter of plant site	Coordinates	Significance
HH01 Main residence	123 m	28º 10.647'S 26º 37.032'E	**Med-low**
HH02 1st outbuilding HH03 2nd outbuilding	120 m 96 m	28º 10.652'S 26º 37.028'E	
SH01 Possible milk shed	165 m	28º 10.672'S 26º 36.983'E	
WS02 Wagon shed	170 m	28º 10.640'S 26º 36.986'E	**Med-low**
WS03 Wagon shed	187 m	28º 10.652'S 26º 36.996'E	**Med-low**
Other (recent) buildings		Not geo-referenced	**Low**
Graveyards		**Coordinates**	**Significance**
GY01. Jordaan graveyard	300 m	28º 10.783'S 26º 36.874'E	**High**
GY02. Informal graveyard	4 400 m	28º 09.329'S 26º 39.428'E	**High**

The historical structures are older than sixty years and therefore qualify as historical remains. All remains older than sixty years are protected by the National Heritage Resources Act. None of the identified historical structures are located on the power plant site and they need not be affected by the project.

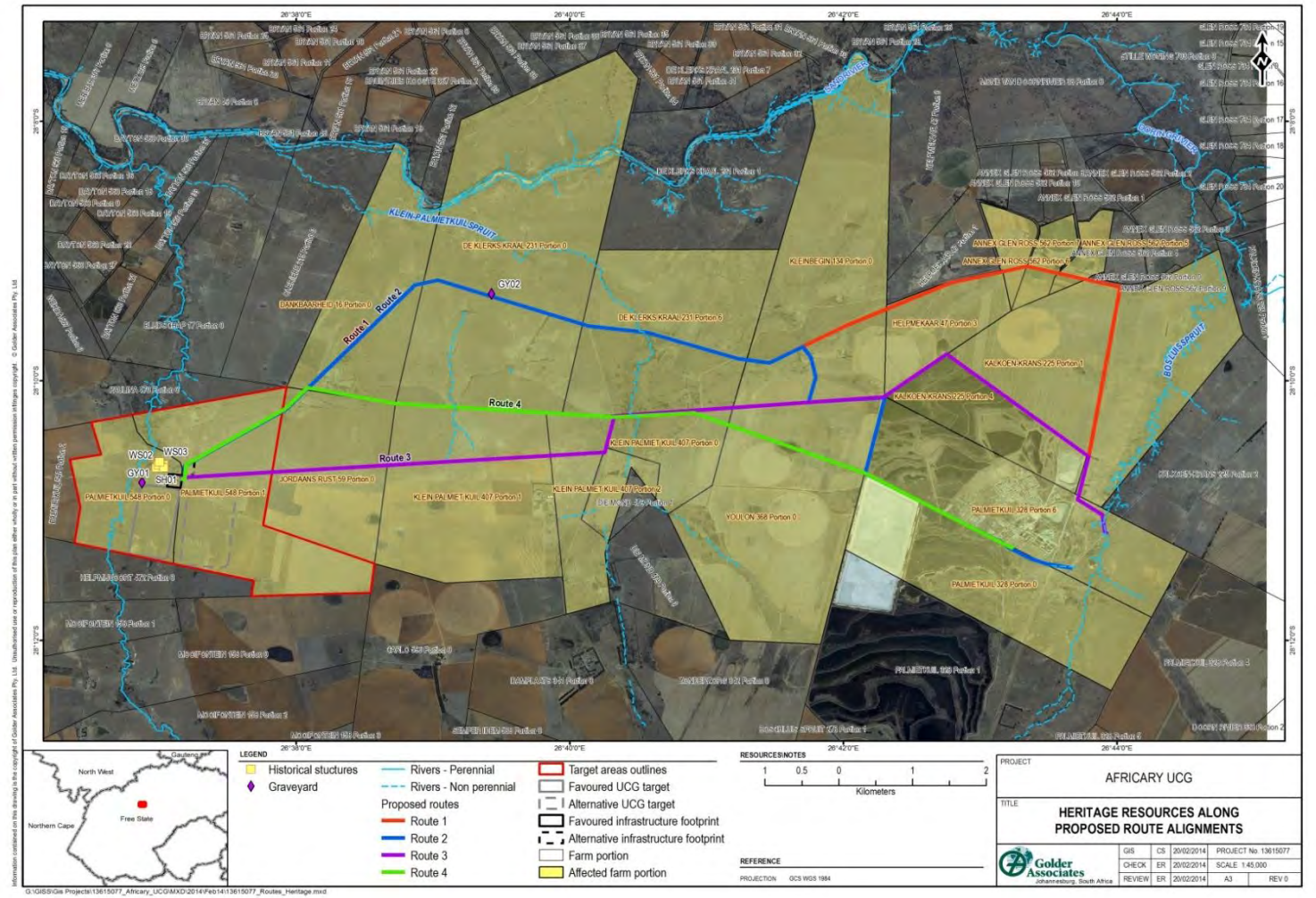


Figure 7-30: Cultural and heritage resources – at site and along route

Figure 7-31: Cultural and heritage resources near power plant site

All graveyards and graves can be considered to be of high significance and are protected by various laws. Legislation with regard to graves includes Section 36 of the National Heritage Resources Act (Act No 25 of 1999) whenever graves are older than sixty years. It seems as if both graveyards are older than sixty years. Other legislation with regard to graves includes those which apply when graves are exhumed and relocated, namely the Ordinance on Exhumations (No 12 of 1980) and the Human Tissues Act (No 65 of 1983 as amended)

GY01 is situated to the west of the proposed stand for the UCG Project's power generator whilst GY02 is situated approximately 20 metres from the shoulder of the dirt road where the electrical power line may run. The two graveyards therefore need not to be affected by the proposed UCG Project.

7.12 Visual aspects

The visual impact assessment was undertaken by a professional landscape architect and visual impact specialist (Bothma, J;, August 2013).

7.12.1 Visual characteristics of the project area

The current, pre-project visual characteristics of the project area were determined by means of a site visit in August 2013, during which a number of photographs were taken and visual observations were made by the specialist.

The regional visual character is largely rural in nature and consists primarily of dryland crop (maize and wheat) production, grazing land and some irrigated land, which is contrasted by extensive gold mining and human settlements to the east and the north of the study area. The visual character of the study area is largely similar to that of the greater region and is illustrated in Figure 7-32.

Although the eastern parts of the Free State are mountainous, the largest part of the Province, including the areas to the west, where the project is located, has generally flat to slightly rolling topography, broken only by drainage lines and the occasional flat-topped hills or mesas. Also characteristic of the western and north-western Free State are natural pan systems, comprising shallow hollows with internal drainage from all sides. The study area itself is completely devoid of any identifiable landforms and is characterised by almost completely flat to gently undulating topography (Figure 7-32).

In contrast to the largely featureless natural topography of the project study area, the areas around Welkom and Virginia, which are located to the northeast and east respectively, are characterised by numerous artificial tailings dams, none of which are visible from the site itself.

Visually, the vegetation cover is largely homogenous in appearance over large parts of the project area and is almost insignificant in some instances, such as where heavy grazing or poor soils and rapid infiltration inhibit plant growth. In the few instances where taller plants do occur, mostly exotic trees associated with farmsteads, these tend to form prominent vertical landmarks in the primarily horizontal visual landscape.

Figure 7-32: Typical flat topography of site (top) and gently rolling topography of study area directly to the north (bottom)

From a visual perspective, none of the watercourses that traverse the study area are prominent over any significant distance, due to their limited channel sizes and to a lesser extent as a result of vegetative screening. Similarly, the numerous pans within the study area are only conspicuous when they contain standing water, which only occurs for short periods of time after rainfall events.

Figure 7-33: The Palmietkuilspruit is not visually prominent in the landscape

7.12.2 Visual resource value of the project area

The visual resource value of a landscape is determined by its aesthetic appeal and visual quality, which in turn depend on the manner in which combinations of its components appeal to the senses. Studies in perceptual psychology have shown human preferences for landscapes with a higher visual complexity, rather than homogeneous ones. Landscape quality and aesthetic appeal increase when:

- Prominent topographical features and rugged horizon lines exist;
- Water bodies such as streams or dams are present;
- Untransformed indigenous vegetation cover dominates; and
- Visible evidence of human activity is limited and confined to land uses that are not visually intrusive.

Table 7-31 summarises criteria used for visual resource assessment. The assessment combines visual quality attributes (views, sense of place and aesthetic appeal) with landscape character and gives the landscape a high, moderate or low visual resource value, within the context of its location.

Table 7-31: Visual resource value criteria

Visual Resource Value	Criteria
High	Pristine or near-pristine condition, little to no visible human intervention, characterised by highly scenic or attractive features that combine to provide an experience of unity, richness and harmony. These are landscapes that may be sensitive to change and particularly worthy of conservation.
Moderate	Partially transformed or disturbed landscape, with noticeable presence of incongruous elements. Human intervention visible but does not dominate the view. Scenic appeal partially compromised. These landscapes are less important to conserve, but may include certain areas or features worthy of conservation.
Low	Extensively transformed or disturbed landscape, with visual prominence of widely disparate or incongruous land uses and activities. Human intervention dominates available views. Scenic appeal greatly compromised, with few, if any, valued features remaining. Scope for positive enhancement.

Based on the findings of the baseline assessment and the above criteria, the visual resource value of the study area is summarised as follows:

- Topography - The flat, featureless topography is similar to that of large parts of the surrounding region and does not contribute to the visual resource value of the study area. The topographical aspect is rated as ***low***;
- Hydrology - The hydrological features within the study area are not visually prominent and only contribute to the visual resource value on a local scale and over short-range views. Hence, this aspect is rated as ***moderate;***
- Vegetation cover - Large parts of the study area have been transformed by agriculture, and the vegetation is not visually prominent. It is rated as having a ***low*** visual resource value; and
- Land use and land cover - The low impact land uses and resultant land cover found throughout the study area do contribute to the rural and peaceful sense of place and this aspect is rated as being of ***moderate*** significance.

7.12.3 Visual absorption capacity of the project area

Visual absorption capacity (VAC) is the extent to which a landscape can absorb development without creating a significant change in visual character or producing a reduction in scenic quality. (Oberholzer, 2005). It depends on the degree of visual contrast between the proposed new project and the existing elements in the landscape. If, for example, a visually prominent industrial development already exists in an area, the capacity of that section of landscape to visually absorb" additional industrial structures is higher than that of a similar section of landscape that is still in its natural state. VAC is therefore primarily a function of the existing land use and cover, in combination with the topographical ruggedness of the study area and immediate surroundings.

Based on the flat to gently rolling topography, visually homogenous vegetation cover and low levels of development and landscape transformation, the VAC of the study area is rated as being ***low***.

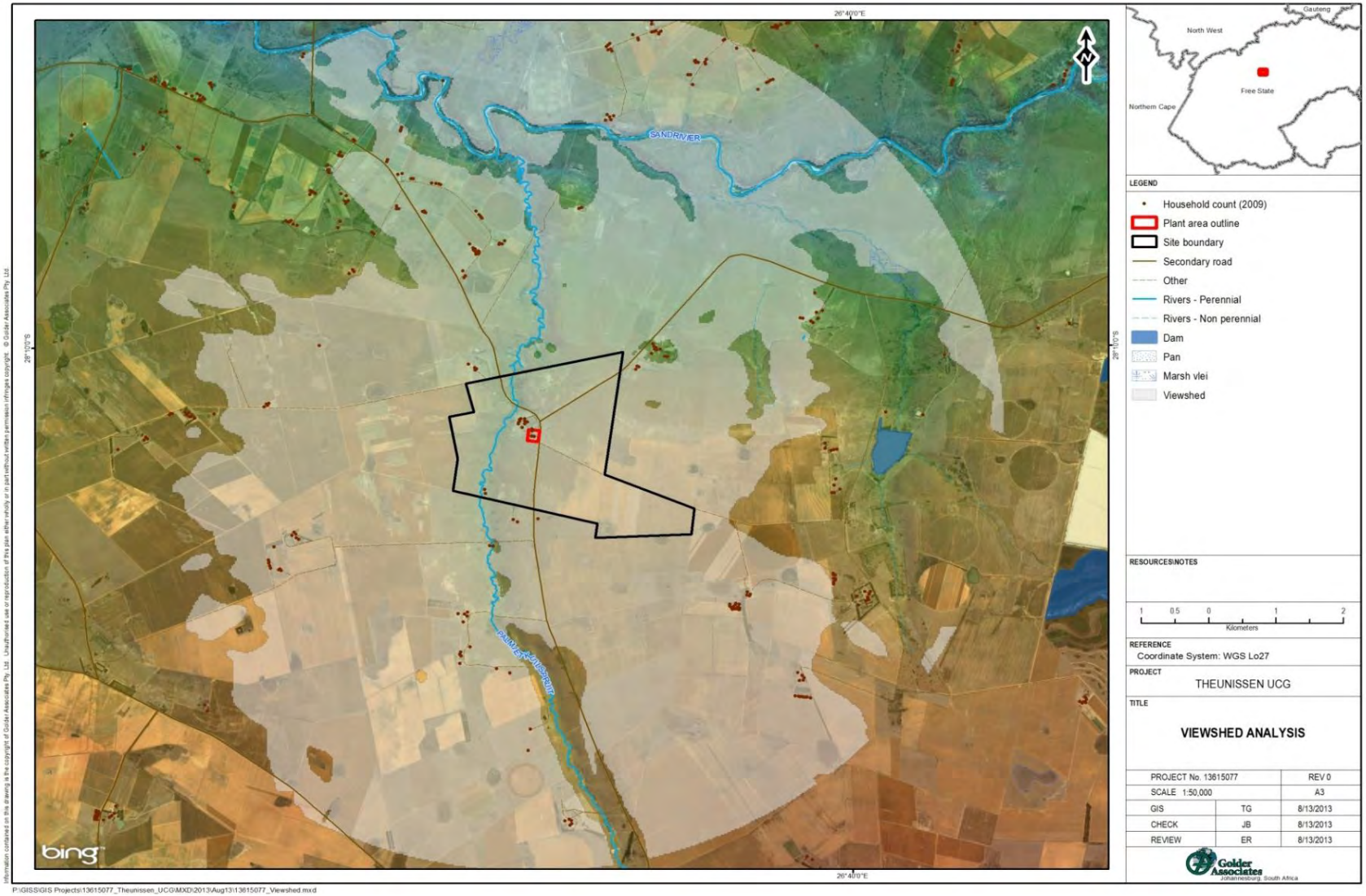


Figure 7-34: Areas from which power plant will be visible

7.12.1 Receptor sensitivity

Potential viewers, or visual receptors, are generally either people who live or work in the project area (resident receptors, frequent exposure) or people who travel through the area (transient receptors, low incidence of exposure).

There are only a small number of resident receptors and relatively little traffic along the roads that fall within the viewshed shown in Figure 7-34, which indicates the areas from which the power plant structures will be visible. Because the area is largely rural and the nearest mining infrastructure is not visible from the proposed power plant site, local residents may well experience the power plant and its ancillaries as visually intrusive.

8.0 IMPACTS AND RISKS IDENTIFIED

The findings of the specialist studies, which guided the selection of the preferred site and final site layout, are presented in section 11.0 of this EIA/EMPr report. The complete specialist reports are attached as APPENDIX H. The specialists' findings were used to assess the project's impacts and risks during its complete life cycle, from the construction phase, through the operational phase, to the closure and rehabilitation phase.

9.0 IMPACT ASSESSMENT PROCESS AND METHODOLOGY

The overall process and methodology that was followed during the EIA was designed to satisfy the requirements of the South African legislation (specifically NEMA and MPRDA), as well as South African and best practice guidelines, specifically the IFC standards.

The scoping phase included the following activities:

- Analysis of existing information against the project compliance criteria and regulatory requirements;
- Project description and analysis of alternatives – inclusive of data review, red flag and constraints mapping, input to alternatives analysis and preferred layout planning;
- Legislative and process review of all applicable compliance criteria;
- Environmental and Social baseline studies by specialists – carrying out monitoring, data collection and fieldwork to determine the baseline conditions of the environment that could be affected by the project;
- Stakeholder Engagement – was undertaken throughout the Scoping process to record issues and comments received from the public. These issues and comments were integrated into the process and were considered in the impact assessment phase of the EIA.
- Scoping (identification of key issues and development of plan of study for carrying out the impact assessment). The Scoping Report was presented to the public and the South African Government departments dealing with mining and environmental authorisations for comment from 4 October to 3 November 2016. The final Scoping Report was submitted to the DMR on 14 December 2016;

The following activities were undertaken during the impact assessment phase of the EIA:

- Impact Assessment *via* specialist studies – evaluation of potential impacts and benefits of the project utilising qualitative and quantitative evaluation on environmental aspects and issues identified during the scoping phase;
- Environmental and Social Management Systems Development – establishment of a system for the management of environmental and social impacts supported by action plans;
- Preparation of an EIA/EMPr report – documenting all processes and presenting the findings of the impact assessment. The EIA/EMPr report is available to the public and the relevant South African Government departments for comment from 15 May 2017 until 14 June 2017. The final EIA/EMPr report will be submitted to the DMR after 14 June 2017 for a decision on whether the project may proceed and if so, under what conditions; and

- Stakeholder Engagement – will continue throughout the remainder of the EIA process to record issues and comments received from interested and affected parties. All issues and comments will be integrated into the process and considered during the EIA.

The overarching principles that guided the EIA include:

- Sustainability – development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs;
- Mitigation hierarchy – The mitigation hierarchy describes a step-wise approach that illustrates the preferred approach to mitigating adverse impacts as follows (the governing principle is to achieve no net loss and preferably a net positive impact on people and the environment as a result of the project):
  1) The preferred mitigation measure is **avoidance;**
  2) Then **minimisation;**
  3) Then **rehabilitation** or **restoration**; and
  4) Finally **offsetting** residual, unavoidable impacts.
- Duty of care towards the environment and affected people.

The assessment of the impacts of the proposed activities was conducted within the context provided by these principles and objectives.

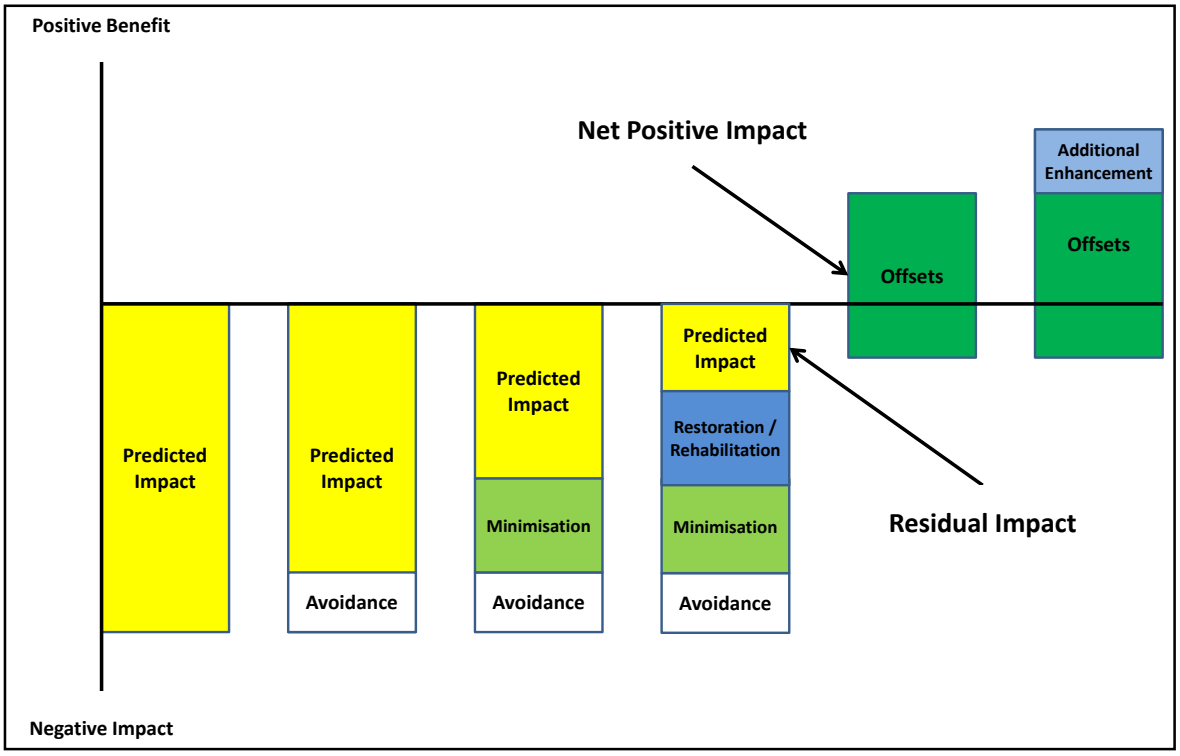


Figure 9-1: Mitigation Hierarchy adapted from BBOP (2009)

9.1 Scoping Methodology

The methodology specifically adopted for the scoping phase included the following:

- Stakeholder consultation as described in section 6.0 and **Error! Reference source not found.** of this report;
- Review of existing data;
- Fieldwork by the EIA specialist team to obtain additional baseline data;

- Workshops with the specialist team to identify key impacts and issues and to outline the plan of study; and
- Compiling the Scoping report.

9.2 Impact Assessment Methodology

The significance of the identified impacts were determined using the approach outlined below (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998). This approach incorporates two aspects for assessing the potential significance of impacts, namely occurrence and severity, which are further sub-divided as follows:

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Scale / extent of impact	Magnitude (severity) of impact

To assess each of these factors for each impact, the following four ranking scales are used:

Probability	Duration
5 - Definite/don't know	5 - Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8-15 years)
2 - Low probability	2 - Short-term (0-7 years) (impact ceases after the operational life of the activity)
1 – Improbable	1 – Immediate
0 – None	
SCALE	**MAGNITUDE**
5 – International	10 - Very high/don't know
4 – National	8 - High
3 – Regional	6 - Moderate
2 – Local	4 - Low
1 - Site only	2 - Minor
0 – None	

Once these factors are ranked for each impact, the significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). The impact significance will then be rated as follows:

SP >75	Indicates high environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates moderate environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates low environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.

+	Positive impact	An impact that constitutes an improvement over pre-project conditions

9.3 Positive and negative impacts of initial site layout and alternatives

The main impacts and risks determined for the preferred site and layout as illustrated in Figure 2-7, Figure 5-1 and Figure 5-5 are briefly summarised below. See section 11.0 for a comprehensive description of the impacts.

1) **Atmospheric pollution**: Maximum concentrations of criteria pollutants are unlikely to be exceeded at any sensitive receptor points.The impact is expected to be of ***moderate*** significance and completely reversible after closure. If the flaring system fails when it is necessary to flare, unburnt producer gas containing CO, CH_4, phenols and other organic compounds will be emitted to the atmosphere. If the gas cleaning system fails or does not work effectively, particulates and sulphur compounds will be emitted to the atmosphere,

2) **Groundwater pollution**: With proper implementation of the recommended mitigation measures, the potential for any impact on the shallow aquifer is expected to be ***low*** and completely reversible. Inadequate casing and grouting of the injection and production boreholes could result in producer gas leaking into the shallow aquifer. Leakage through the brine pond and/or pollution control dam liners could occur and contaminate the shallow aquifer. Metals and combustion products could be leached from the ash in the spent combustion chamber and contaminate the deep aquifer, but it would be a very slow process due to the low hydraulic conductivity of the host rock. The effect would dissipate over decades.

3) **Surface water**: With proper management of surface water systems, the expected potential for surface water pollution is ***low.*** Spillage from the brine pond and/or pollution control dam could enter the Palmietkuilspruit and flow into the Sand River. Such an impact would dissipate quite rapidly;

4) **Ecology**: The project will remove indigenous and alien vegetation from an area of about 3 ha at the infrastructure site and temporarily disturb vegetation over an area of about 30 ha along the power line route, resulting in an impact of ***moderate*** significance, that would be largely reversible after closure***;***

5) **Noise:** With normal mitigation measures the noise levels created by gas turbines would be intrusive at three receptors, an impact of ***high*** significance, but with gas engines the noise level would be intrusive at only one receptor, to the north of the infrastructure site, an impact of ***moderate*** significance, that would be completely reversible at closure;

6) **Visual:** The structures on the infrastructure site will stand out in the rural landscape. Due to the flat terrain and lack of adequate screening vegetation, a ***moderate*** and completely reversible visual impact is expected;

7) **Soil, land use and land capability:** Risks of erosion and contamination with hydrocarbons exist, but with proper implementation of mitigation measures, the potential impact is of ***low*** significance and reversible;

8) **Socio-economic:** The project will create only about 33 jobs and the annual operating cost is small compared to the regional GDP, resulting in an expected positive impact of ***low*** significance;

9) **Cultural and heritage:** There are two graveyards close to, but not within the footprint of the project infrastructure. They need not be disturbed and the potential for impact resulting from the project is ***low***.

9.4 Possible mitigation measures and levels of risk

The risks are referenced in section 7.12.1 above. For a comprehensive description of recommended mitigation measures see section 11.0 of this report.

9.5 Motivation where no alternative sites were considered

Not applicable. Alternative sites were considered. See sections 5.1 and 5.2 of this report.

9.6 Statement motivating the preferred site and layout

The site and power line route locations and layouts shown on Figure 2-7, Figure 5-1 and Figure 5-5 and represent the best overall option as determined by environmental and cost considerations.

9.7 Process undertaken to identify, assess and rank impacts and risks imposed on preferred site.

The process involved impacts assessed in accordance with South African regulatory requirements, best practice and guidelines (domestic and international) as discussed in section 3.0 of this report, public consultation as set out in section 6.0 and **Error! Reference source not found.**, the methodologies described in section 9.0 and the specialist investigations described in section 11.0.

Alternative infrastructure site locations and layouts to the preferred one illustrated in Figure 2-7, Figure 5-1 and Figure 5-5 were evaluated on the basis of the following criteria:

- **Environmental**: There are a number of geophytes growing on the alternative infrastructure site on the eastern side of the road. The preferred site on the western side has undergone more anthropogenic change. The preferred route for the power distribution line shown on Figure 5-5 was selected based on the lowest environmental and social impact; and
- **Cost**: There is an existing farmhouse, with an access road and electricity and sewage connections, that can be used as offices, on the infrastructure site on the western side of the road. There is little to choose between the two alternative UCG target areas indicated on Figure 5-1, as they will have no impacts at surface, but if the target area is on the other side of the road from the infrastructure site, pipelines and cables between the site and the target area would have to cross the road.

10.0 ENVIRONMENTAL IMPACT ASSESSMENT

The proposed underground coal gasification and power generation project has a potential to impact on some biophysical and socio-economic aspects of the local environment.

One of the main purposes of the EIA process is to understand the significance of these potential impacts and to determine to what extent they can be minimised or mitigated. Based on experience with and past studies on similar operations, supported by site-specific specialist studies, the impacts on soils, surface water, groundwater, air quality, the ecology and the local socio-economic fabric can be predicted and appropriate mitigation measures can be formulated.

The EIA process for this project has been designed to comply with the requirements of the NEMA and the EIA Regulations as well as the MPRDA and the MPRD Regulations. Cognisance will also be taken of the following key principles contained in the NEMA, which is South Africa's framework environmental legislation:

- Sustainability – development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs;
- Mitigation hierarchy – avoidance of environmental impact, or where this is not possible, minimising the impact and remediating the impact; and
- The duty of care of developers towards the environment.

The cumulative effects of project impacts within the local region were also considered.

Based on the findings of the EIA, a comprehensive Environmental Management Programme (EMPr) has been developed to control and minimise the impacts during construction, operation and decommissioning of the proposed project.

10.1 Project Phases and Activities

The environmental impacts of the project were assessed for the:

- Construction phase;
- Operational phase; and
- Closure and rehabilitation phase.

Potential cumulative impacts were also identified and assessed for each component, where applicable.

10.1.1 Construction

The **Construction Phase** marks the beginning of physical changes to the site. During this phase, the following activities will take place:

- Surveying and pegging out of the construction areas for the power generation plant, its supporting infrastructure, and the power line from the site to the Eskom grid connection point;
- Excavation of the bunded areas, building foundations, pipe trenches, water diversion channels and basins for the brine ponds;
- Construction of the access road and the stormwater management system (upslope diversion berms and clean water collection drains);
- Construction of foundations and buildings for power generation plant, gas preparation plant, water treatment plant, air enrichment system, workshops and offices;
- Installation, testing and cold commissioning of equipment;
- Installation of power reticulation and raw water feed systems;
- Drilling of injection and production wells;
- Installation, testing and cold commissioning of instrumentation and control systems for operation of the UCG process;
- Digging a 1 metre deep trench for the water pipeline to supply the plant, laying the pipe, backfilling the trench and re-vegetating the disturbed surface;
- Digging post holes, planting poles and stringing the power line; and
- Landscaping and re-vegetation of bare areas on the site.

It is anticipated that the construction phase will take approximately 12 to 15 months to complete.

10.1.2 Operation

During the **Operational Phase**, the project components will be hot commissioned, the UCG process will be initiated and power generation will commence. Activities will comprise:

- Pumping air enriched with oxygen into the injection well to initiate combustion of the underground coal;
- Adding water to the injected air and adjusting the O_2 content to maintain the desired gasification parameters;
- Removing the produced syngas *via* the production borehole;
- Preparing the syngas for combustion in the gas engines;
- Producing power and feeding it into the national grid;
- Continuous monitoring of the UCG process;
- Maintaining the water table by saturation of surface (water injection);
- Periodic relocation of the injection and production wells during the operational life of the project; and
- Regular monitoring of environmental performance against the EMP and the permitting conditions.

The operational phase of the UCG Project is expected to continue for at least 20 years.

10.1.3 Closure and rehabilitation

The expected lifespan of the project as described in this EIA Report is 20 years. At that time underground coal gasification could be undertaken in another area of the coalfield and the power plant could be refurbished or expanded at that site, or it could be closed and replaced by a larger power plant at another site, using such new technologies as may have become available. Such activities would be subject to environmental legislation prevailing at that time.

If the power plant at the proposed site is closed, the activities during the **Closure and rehabilitation Phase** will include:

- Dismantling of the plant and removal of all metal structures;
- Demolition of buildings and infrastructure and disposal of the rubble;
- Emptying of the brine ponds, removal and disposal of the brine and synthetic liner materials and mixing of the clay liners into the underlying subsoil by ripping and ploughing;
- Either leaving the dam basin to develop into a seasonal wetland or backfilling the water conveyance channels and the dam basin;
- Re-vegetation of all bare areas on the project footprint with locally indigenous species; and

Post-closure monitoring of environmental performance against the EMP and permitting conditions for at least five years.

11.0 FINDINGS OF THE ENVIRONMENTAL IMPACT ASSESSMENT STUDIES

11.1 Air quality

11.1.1 Ambient air quality standards and guidelines

The South African ambient air quality standards, which were set by the publication of Government Notice 1210 in Government Gazette no 32816 on 24 December 2009, are as listed in Table 11-1.

Table 11-1: South African Ambient Air Quality Standards for Criteria Pollutants

Pollutant	Averaging Period	Limit Value ($\mu g/m^3$)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
NO_2 (a)	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
PM_{10} (b)	24 hour	120	-	4	Immediate – 31 December 2014
	24 hour	75	-	4	1 February 2015
	1 year	50	-	0	Immediate – 31 December 2014
	1 year	40	-	0	1 February 2015
O_3 (c)	8 hours (running)	120	61	11	Immediate
Lead (Pb) (d)	1 year	0.5	-	0	Immediate
CO (e)	1 hour	30000	26000	88	Immediate
	8 hour (calculated on 1 hourly averages)	10000	8700	11	Immediate
Benzene (C_6H_6) (f)	1 year	10	3.2	0	Immediate – 31 December 2014
	1 year	5	1.6	0	1 February 2015

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
SO_2 (g)	10 minute	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hours	125	48	4	Immediate
	1 year	50	19	0	Immediate
$PM_{2.5}$ (h)	24 hours	65		4	Immediate – 31 December 2015
	24 hours	40		4	1 January 2016 – 31 December 2029
	24 hours	25		4	1 January 2030
	1 year	25		0	Immediate – 31 December 2015
	1 year	20		0	1 January 2016 – 31 December 2029
	1 year	15		0	1 January 2030

Notes:

a. *The reference method for the analysis of NO_2 shall be ISO 7996*
b. *The reference method for the determination of the particulate matter fraction of suspended particulate matter shall be EN 12341*
c. *The reference method for the analysis of ozone shall be the UV photometric method as described in ISO 13964*
d. *The reference method for the analysis of lead shall be ISO 9855*
e. *The reference method for analysis of CO shall be ISO 4224*
f. *The reference methods for benzene sampling and analysis shall be either EPA compendium method TO-14 A or method TO-17*
g. *The reference method for the analysis of SO_2 shall be ISO 6767*
h. *The reference method for the analysis of $PM_{2.5}$ shall be EN14907*

On 1 November 2013 the Department of Water and Environmental Affairs (DWEA), published the National Dust Control Regulations R.827 (Government Gazette no 36974) that stipulate the following as acceptable dust fallout rates as measured (using ASTM D1739:1970 or equivalent) at and beyond the boundary of the premises where dust originates:

- For residential areas, dust fallout < 600 mg/m^2/day averaged over 30 days. Permitted frequency of exceedance is two per year, not in sequential months; and
- For non-residential areas, dust fallout < 1200 mg/m^2/day averaged over 30 days. Permitted frequency of exceedance is two per year, not in sequential months.

The air quality officer may require Africary to undertake dust fall and PM_{10} monitoring.

It is important to note that people experience dust deposition as a nuisance effect, and that there are no direct human health implications because the dust is not inhaled. Indirect effects on human and animal health may result from the deposition of dust containing toxicants onto edible plants. Heavy dust deposition can have detrimental effects on plants if the leaves are smothered to the extent where transpiration and photosynthesis are affected.

11.1.2 Emission standards

11.1.2.1 Current South African emission standards

The NEMAQA makes provision for the setting and formulation of national ambient air quality and emission standards that can be set more stringently on a provincial and local level if necessary. In terms of Section 21 of the NEMAQA, a listed activity is an activity which 'results in atmospheric emissions that are regarded to have a significant detrimental effect on the environment, including human health'.

The UCG project is most likely to fall within the ambit of the following activities listed in Government Notice No. 893 of 23 November 2013:

Category 1: Combustion installations:

- Subcategory 1.5 Reciprocating engines Table 11-2 will be applicable to the gas engines used for power generation.

Category 3: Carbonisation and coal gasification:

- Subcategory 3.1 Combustion installations (Table 11-3) may be applicable to the underground gasification of the coal, although combustion for the purposes of steam raising or electricity generation is excluded.
- Subcategory 3.2 Coke production (Table 11-4) may be applicable to the by-product recovery processes.
- Subcategory 3.6: Synthetic Gas Production and Clean-up Table 11-5 will be applicable to the gas treatment plant.

The project also has the potential to fall under several other listed activities, which are discussed in some detail in the specialist air quality report (Allan, C; Coetzee, L;, October 2013). The applicable listed activities to be included in the application for an atmospheric emission licence will be determined by the Lejweleputswa District Municipal Air Quality Officer.

Table 11-2: Subcategory 1.5

Category 1	**Combustion installations**		
Subcategory 1.5	Reciprocating Engines		
Description:	Liquid and gas fuel stationary engines used for electricity generation.		
Application:	All installations with design capacity equal to or greater than 10 MW heat input per unit, based on the lower calorific value of the fuel used.		
Substance or mixture of substances		**Plant status**	**mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa**
Common name	**Chemical symbol**		
Particulate matter	N/A	New	50
		Existing	50
Oxides of nitrogen	NO_x expressed as NO_2	New	2000* - 400**
		Existing	2000* - 400**
Sulphur dioxide	SO_2	New	1170*
		Existing	1170*

* Liquid fuels fired ** Gas fired

Table 11-3: Subcategory 3.1

Category 3	**Carbonisation and coal gasification**		
Subcategory 3.1	Combustion installations		
Description:	Combustion installations not primarily used for steam raising or electricity generation		
Application:	All combustion installations (except test or experimental)		
Substance or mixture of substances		**Plant status**	**mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa**
Common name	**Chemical symbol**		
Particulate matter	N/A	New	50
		Existing	100
Oxides of nitrogen	NO_x expressed as NO_2	New	700
		Existing	2000
Total volatile organic compounds (from non-coke oven operations)	N/A	New	40
		Existing	90

a) The following special arrangements shall apply –
i) Sulphur-containing compounds to be recovered from gases to be used for combustion with a recovery efficiency of not less than 90% or remaining content of sulphur containing compounds to be less than 1000mg/Nm^3 measured as hydrogen sulphide, whichever is strictest.

Category 3	Carbonisation and coal gasification
ii)	Where co-feeding with waste materials with calorific value allowed in terms of the Waste Disposal Standards published in terms of the Waste Act, 2008 (Act 59 of 2008) occurs, additional requirements under subcategory 1.6 shall apply.

Table 11-4: Subcategory 3.2

Category 3	**Carbonisation and coal gasification**		
Subcategory 3.2	Coke production		
Description:	Coke production and by-product recovery from these operations		
Application:	All installations		
Substance or mixture of substances		**Plant status**	**mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa**
Common name	**Chemical symbol**		
Hydrogen Sulphide	H_2S	New	7 (from point source)
		Existing	10 (from point source)

Table 11-5: Subcategory 3.6

Category 3	**Carbonisation and coal gasification**		
Subcategory 3.6	Synthetic Gas Production and Clean-up		
Description:	The production and clean-up of a gaseous stream derived from coal gasification and includes gasification, separation and clean-up of a raw gas stream through a process that involves sulphur removal and Rectisol as well as the stripping of a liquid tar stream derived from the gasification process.		
Application:	All installations		
Substance or mixture of substances		**Plant status**	**mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa**
Common name	**Chemical symbol**		
Hydrogen Sulphide	H_2S	New	3 500
		Existing	4 200
Total volatile organic compounds	N/A	New	130
		Existing	250
Sulphur dioxide	SO_2	New	500
		Existing	3 500

11.1.3 International guidelines

11.1.3.1 Emission guidelines

The IFC published emission guidelines for natural gas fired reciprocating engines in the Environmental, Health, and Safety Guidelines for Thermal Power Plants (2008). See Table 11-6. These guidelines are more stringent than the South African standards for reciprocating engines and provide a conservative, internationally recognised benchmark for comparison.

Table 11-6: Emissions guidelines for natural gas reciprocating engines (mg/Nm3)

Reciprocating engine	**Particulate Matter**	**Sulphur Dioxide (SO_2)**	**Nitrogen Oxides (NO_x)**	**Dry Gas, Excess O_2 Content (%)**
Natural gas	Emission impacts are required to comply with ambient air quality standards/guidelines		200 (Spark ignition) 400 (Dual Fuel)	15%

11.1.3.2 Ambient air quality guidelines

The current World Health Organization (WHO) Air Quality Guidelines, which are also used by the IFC in the absence of national standards, are summarized in Table 11-7.

Table 11-7: Ambient Air Quality Standards (µg/m³)

Pollutant	Averaging period	IFC Guideline	World Health Organisation(*)			
			Guideline	Interim Target 1	Interim Target 2	Interim Target 3
Carbon Monoxide	8 hours	-	-	-	-	-
	1 hour	-	-	-	-	-
Lead	Annual	-	-	-	-	-
	1 hour	-	-	-	-	-
Ozone	Annual	-	-	-	-	-
	24 hours	-	-	-	-	-
	1 hour	-	-	-	-	-
TSP	Annual	80				
	24 hours	230	-	-	-	-
PM_{10}	Annual	50	20	70	50	30
	Maximum 24 hour	150	50	150	100	75
$PM_{2.5}$	Annual	-	10	35	25	15
	Maximum 24 hour	-	25	75	50	37.5
NO_2	Annual	100	40	-	-	-
	Maximum 24 hour	150	-	-	-	-
	Maximum 1 hour	-	200	-	-	-
SO_2	Annual	80	-	-	-	-
	Maximum 24 hour	150	20	125	50	-
	Maximum 1 hour	-	-	-	-	-

* WHO Global Update (2005) and IFC EHS Air Emissions and Ambient Air Quality reference to the WHO guidelines

11.1.4 Key pollutants and associated health effects

The health effects of acute and chronic exposure to the key atmospheric pollutants commonly encountered in industrialised countries are summarised in Table 11-8. A complete discussion is included in the specialist report (Allan, C; Coetzee, L;, October 2013).

Table 11-8: Summary of acute and chronic health effects associated with exposure to the primary pollutants (WHO, 2004)

Pollutant	Acute exposure	Chronic exposure
Carbon Monoxide (CO)	• Severe hypoxia , can lead to death • Headaches, nausea & vomiting • Muscular weakness • Shortness of breath	• Neurological deficits and damage
Sulphur dioxide (SO_2)	• Reduction in lung function • Respiratory symptoms (wheeze and cough) • Increase in hospital admissions • Increase in mortality	• Increase in respiratory symptoms • Reduction in lung function, especially in asthmatics and children • Reduction in life expectancy • Increase in mortality
Nitrogen dioxide (NO_2)	• Effects on pulmonary function, especially in asthmatics • Increase in airway allergic inflammatory reactions • Increase in hospital admissions • Increase in mortality	• Reduction in lung function • Increased probability of respiratory symptoms • Reduction in life expectancy • Increase in mortality

Pollutant	Acute exposure	Chronic exposure
Particulate matter (TSP, PM_{10} and $PM_{2.5}$)	• Airway allergic inflammatory reactions & a wide range of respiratory problems • Increase in medication usage related to asthma, nasal congestion and sinuses problems • Adverse effects on the cardiovascular system • Increase in hospital admissions • Increase in mortality	• Increase in lung problems with lower respiratory symptoms • Reduction in lung function in children and adults • Increase in chronic obstructive pulmonary disease • Reduction in life expectancy • Reduction in lung function development
Volatile organic compounds (VOCs)	• Adverse effects on the cardiovascular system and central nervous system • Increase in mortality	• Neurological and cardiovascular system damage • Reduction in life expectancy • Increased prevalence of carcinomas in the community • Increase in mortality
Hydrogen Sulphide (H_2S)	• Irritation to the eyes, nose, or throat • Difficulty in breathing for some asthmatics • Loss of consciousness • Headaches, poor attention span, poor memory, and poor motor function • In extreme cases, death	• Does not accumulate in the body, therefore there are no long term effects.

11.1.5 Emissions inventory

Potential sources of emissions associated with the UCG facility were identified to include:

- Emissions associated with construction;
- Vehicle entrained dust from both paved and unpaved road surfaces (primarily during construction);
- Gas generated through the coal gasification processes;
- Venting air during start-up to dry the gasifier for normal operation;
- Flaring of the UCG pilot plant and safety valves during regular or upset conditions;
- Gas engine exhaust emissions; and
- CO_2 released from the Super Critical Water Oxidation (SCWO) process.

Construction and land clearing give rise to fugitive dust emissions with temporary impacts on local air quality, but they are easily controlled. Due to their short term nature, dispersion modelling was not undertaken.

Given the population densities in the region and the limited additional traffic due to Africary's activities, vehicle exhaust emissions are not expected to make a significant contribution and were not included in the dispersion modelling simulations.

UCG gas composition varies depending on the conditions under which it is generated. Table 11-9 shows the typical composition of UCG gas as it occurs at the well-head, before it is cleaned.

Table 11-9: Composition of UCG gas according to literature, compared with field measurements

Pollutant	Typical dry raw gas composition for low-rank, high moisture, low ash coal (air blown)	Typical dry raw gas composition for sub-bituminous/bituminous, high ash coal (oxygen-enriched air)	Composition (%) according to field measurements at Rocky Mountain*
Methane (CH_4)	5-14%	8-14%	6.4%
Hydrogen (H_2)	25-40%	10-20	27.3%
Carbon dioxide (CO_2)	25-40%	10-20	27.2%
Carbon monoxide (CO)	5-20%	25-40	6.4%
Hydrogen Sulfide (H_2S)	2-8%		-
Nitrogen (N_2)	-	22-30	-
Water (H_2O)	33%		33%

* Measurements taken during the 1980s Rocky Mountain Controlled Reaction Ignition Point test (Walter, 2007)

Air used to dry the gasifier will be vented prior to start-up for normal operation. After the gasifier has been ignited venting will only occur under upset/emergency conditions. The likelihood of this occurring is relatively low, estimated once in 5 years. Based on information provided by Africary, the emission rate for CO during venting was estimated to be 4 324 g/s.

The gas will normally be transferred to primary cooling, with no release to atmosphere. It will be flared only during initial start-up and emergencies. Based on USEPA emission factors and information provided by Africary, the following emission rates were estimated:

- CO: 21g/s;
- NO_x: 4g/s; and
- SO_2: 71g/s.

Based on USEPA emission factors for reciprocating engines (USEPA,2000) and information provided by Africary, the following emissions rates were estimated for the Four Stroke Lean Burn (4SLB) Gas Fired Reciprocating Engine:

- CO: 0.4829g/s (controlled);
- NO_x: 3g/s (controlled); and
- SO_2: 71g/s (uncontrolled).

Additional rates were estimated for NO_x based on the amended South African national listed activities (Gazette Number 35894, 2012) Subcategory 1.5: Reciprocating Engines, as well as IFC standards for reciprocating engines. These rates were used to show the potential dispersion of NO_x if the facility were to emit at the maximum specified emissions rate.

- NO_x (SA): 64g/s; and
- NO_x (IFC): 32g/s.

SCWO emissions will consist only of CO_2, O_2, N_2 and water vapour and were not included in the dispersion modelling simulations.

11.1.6 Impact Assessment

Three farm houses located at distances of up to 2 km of the power plant site were identified as potentially sensitive receptors. See Figure 11-1.

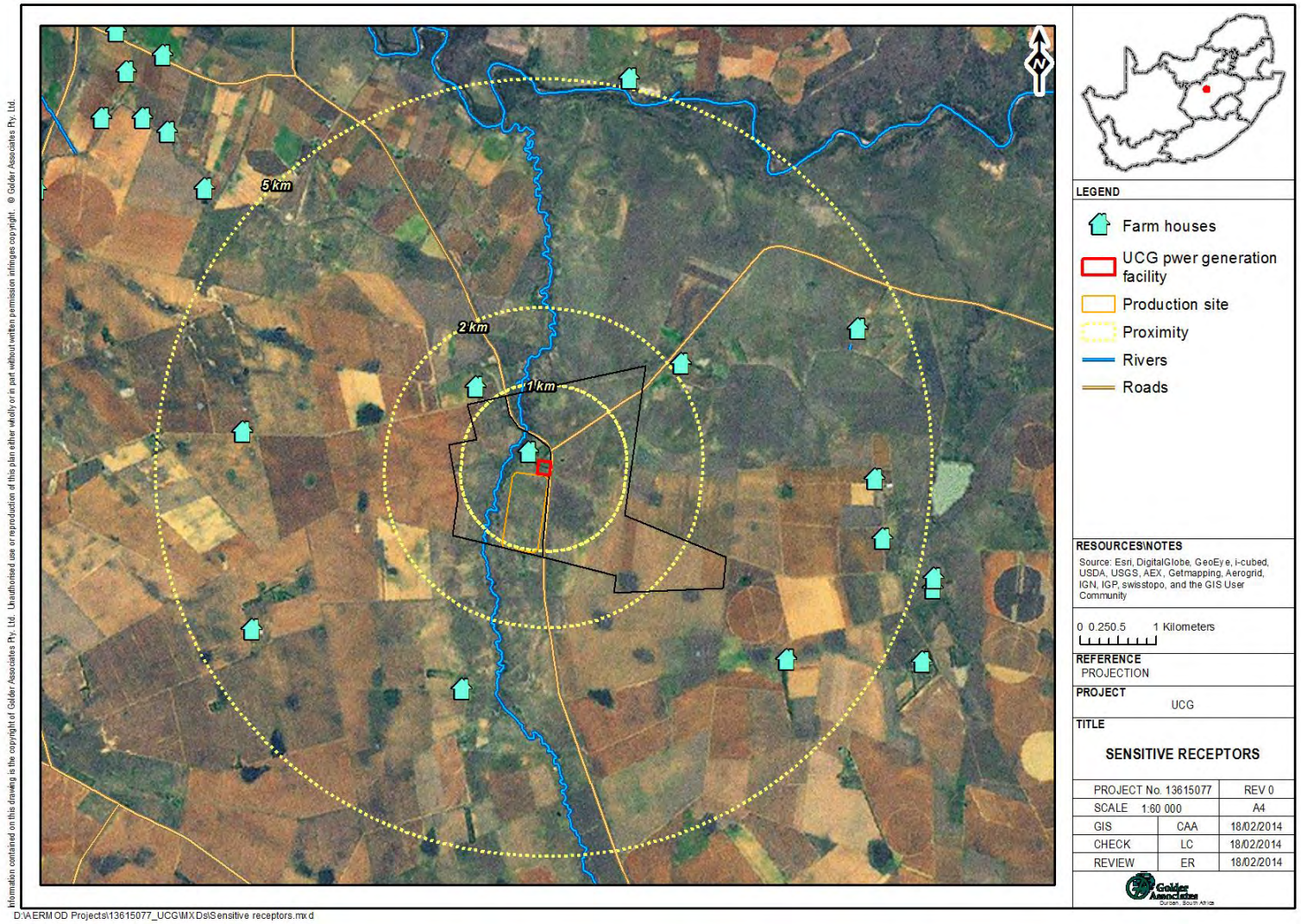


Figure 11-1: Land use and sensitive receptors in the vicinity of the proposed power plant site

11.1.6.1 Construction

The construction activities described in section 10.1.1 will give rise to the mobilisation of particulates (dust and PM_{10}) and emission of exhaust gases from construction vehicles.

Considering the number of vehicles involved in comparison with the existing level of vehicular activity in the area and the relatively short duration of the construction period, the exhaust emissions from the construction vehicles will make a negligible contribution to the ambient air quality and their contribution does not warrant any further consideration.

Mobilisation of particulates will be due to the earthmoving activities (site preparation, excavation of foundations, storm water collection channels, pipeline trenches and the basins for the brine ponds), and entrainment by the wheels of the excavators and loaders and the trucks transporting excavated material on unpaved roads for use in construction or the repair of existing erosion rills. Wind erosion of exposed areas will also make a minor contribution on dry, windy days.

While PM_{10} can travel considerable distances, depending on climatic conditions, the concentration of PM_{10} originating from the relatively small area source representing the project construction activities would fall rapidly with distance from the source due to dispersion and the PM_{10} concentration as a result of these activities is very unlikely to exceed the standard at any public receptor points. Coarser particles will settle as dust within a few metres of the source.

Considering the dominant north-easterly winds, construction activities are more likely to impact farms and farm houses lying to the south, south-west and west of the construction site. The impacts will be more of a nuisance value than a potential health risk.

It is expected that air quality will be poorer during the winter months as a result of temperature inversions and the cumulative effects of pollution caused by the burning of coal and wood in households, and from veld fires that are common in winter.

Based on the site characteristics, the nature and duration of the construction work to be undertaken, the ease with which particulate emissions can be controlled, the location of public receptors, and extensive experience on similar construction projects, dispersion modelling for the construction activities was not considered to be necessary, and only a qualitative assessment has been done.

Without mitigation, the air quality impact during the construction phase is rated as being of ***moderate (SP = 50)*** significance.

The following mitigation measures are recommended:

- Wet suppression, applied sparingly, to ensure the absence of visible dust;
- Enforce low vehicle speeds on unpaved roads (< 30 km/h);
- Ensuring that all equipment is well maintained and in good working order;
- Switching equipment and vehicles off when not in use;
- Minimising the area disturbed at any one time;
- Avoiding the use of unsealed roads where possible; and
- Vegetate the disturbed areas with a locally indigenous grass species as soon as possible.

Wet suppression is very effective, but for roads chemical binders such as Dustex or Dust-A-Side could also be used.

Application of the recommended mitigation measures would reduce the impact to one of ***very low (SP = 10)*** significance.

11.1.6.2 Operation

The ICS-AERMOD modelling software code was used to simulate likely ambient air pollutant concentrations in the vicinity of the power plant site. The AERMET pre-processor was used to process MM5 modelled

regional meteorological data for input into ICS-AERMOD. The latter software code calculates likely changes in dispersion plume trajectory and concentration in response to changes in local terrain and meteorology. Input to a dispersion model includes prepared meteorological data, source data, information on the nature of the receptor grid and emissions input data.

11.1.6.2.1 Dispersion modelling results

Dispersion modelling simulations were undertaken for the operation of the proposed power plant and UCG facility within a 50km radius of the site. Although gas turbines and reciprocating gas engines were both considered as alternatives, only the gas engine alternative was modelled, because Africary indicated this to be the preferred alternative and because the gas would be treated for sulphur removal before being used in a turbine, i.e. the gas engine alternative would emit more SO_2 to atmosphere and thus represent the more conservative scenario.

The following scenarios were modelled:

- Scenario 1: Venting during upset conditions
- Scenario 2: Flaring during upset conditions
- Scenario 3: 'Normal' operation of the reciprocating gas engines
  - CO emissions released at the estimated rate of 0.483g/s (USEPA,2000)
  - NO_x emissions released at the estimated rate of 3g/s (USEPA,2000)
  - NO_x emissions released at 32g/s (IFC standard for reciprocating engines, 2008)
  - NO_x emissions released at 64g/s (draft South African standard for reciprocating engines (General Notice No. 964, 2012)); and
  - SO_2 emissions released at the estimated rate of 71g/s (USEPA,2000)

The dispersion modelling results are summarised in Table 11-10 and illustrated in Figure 11-2 to Figure 11-12.

It must be noted that in most simulations, the highest concentrations were identified within the proposed production site *and* approximately 5 - 15km south to south-south-east of the UCG facility. This may be the result of plume buoyancy and the increase in the terrain elevation towards Theunissen. While the simulations indicate the likelihood of the ambient air quality standards being exceeded to be low, complaints may be received from residents in these areas, particularly during upset conditions.

Table 11-10: Results from the dispersion simulations

Scenario	Pollutant	Ambient Air Quality		Figure #	Simulated concentrations
		Averaging period	Standard (µg/m³)		
1. Venting	CO	1 hour	30 000	Figure 11-2	Maximum concentration (23 701µg/m³) will be 79% of the standard. The highest concentration will be ± 5km S to SSE of the facility.
2. Flaring	CO	1 hour	30,000	Figure 11-3	Maximum concentration (19.09µg/m³) will be 0.06% of the standard. The highest concentration will be at the source and ± 10km SSE of the facility, in the vicinity of Theron.
	NO_2	1 hour	200	Figure 11-4	Maximum concentration (21µg/m³) will be 10.5% of the standard. The highest concentration will be at the source and ± 5km SSE of the facility.
	SO_2	1 hour	500	Figure 11-5	Maximum concentration (378µg/m³) will be 75.6% of the standard. The highest concentration will be at the source and ± 5km S to SSE of the facility.
3. 'Normal' operation of reciprocating gas engines	CO	1 hour	30,000	Figure 11-6	Maximum concentration (200.7µg/m³) will be 0.67% of the standard. The highest concentration will be within the proposed power plant site boundary.
		8 hours	10,000	Figure 11-7	Maximum concentration (76.3µg/m³) will be 0.76% of the standard.
	NO_2	1 hour	200	Figure 11-8	Maximum concentration (65.2µg/m³) will be 32.6% of the ambient standard. The highest concentration will be within the proposed power plant site boundary.
		1 year	40	Figure 11-9	Maximum concentration (0.945µg/m³) will be 2.3% of the standard. The highest concentration will be within the proposed power plant site boundary.
	SO_2	1 hour	350	Figure 11-10	Maximum concentration (84.7µg/m³) will be 24.2% of the standard. The highest concentration will be at the source and ± 13km S to SSE of the facility, in the vicinity of Theron.
		24 hour	125	Figure 11-11	Maximum concentration (16.2µg/m³) will be 13.2% of the standard. The highest concentration will be at the source and in the vicinity of Theron.
		1 year	50	Figure 11-12	Maximum concentration (1.55µg/m³) will be 3.1% of the standard. The highest concentration will be within the proposed power plant site boundary.

The following assumptions were made:

- Raw gas will be flared until the gasifiers have reached the turn-down capacity of the above ground facility;
- The flare rate is based on 4 injection wells;
- Syngas processing will commence when production rate reaches approximately 5% of total capacity, equivalent to the supply for one gas engine;
- Emergency events requiring venting/flaring are rare (i.e. potentially once in 5 years);
- Emergency events are typically remedied within 5 minutes;
- The total emergency event duration will usually not exceed 30 minutes;
- An exponential decay in the volume of gas flared or vented is anticipated once the pressure is relieved;
- Once operational, the UCG facility will operate 24 hours a day, 7 days a week, 365 days a year;
- Particulate matter (PM) will be removed during the gas cooling process. PM was therefore excluded from dispersion modelling simulations;
- Four stroke lean burn (4SLB) gas fired reciprocating engines will be used;
- The vent and flare stacks will be 15m high;
- The gas engine exhaust gases will be released to atmosphere at a height of 15m (Note: a lower height will result in less dispersion and higher concentrations close to the site);
- The gas exit velocity will be 22m/s;
- The gas exhaust emissions may be controlled if required through the following mechanisms (or similar):
  - NO_x: Non Selective Catalytic Reduction (NSCR) (99.0% Reduction Efficiency);
  - CO: Non Selective Catalytic Reduction (NSCR) (98.0% Reduction Efficiency);
  - CO: Catalytic Oxidation (CO) (95.0% Reduction Efficiency); and
- SO_2 emissions were assumed to be uncontrolled;
- Oxygen is present at 15%; and
- NO_x was modelled as NO_2. The U.S. EPA has defined a 3-tier approach to NO_2 concentrations:
  - Tier I - total conversion, or all $NO_X = NO_2$;
  - Tier II – use a default NO_2/NO_X ratio of 0.75; and
  - Tier III – case by case detailed screening methods, such as Ozone Limiting Method (OLM) and Plume Volume Molar Ratio Method (PVMRM).

This study adopts conservative methodology i.e. the Tier I approach or 100% conversion assumption.The assessment has the following limitations:

- CO_2 was excluded from the dispersion simulations as this is not considered to be a criteria pollutant; and
- In addition to NO_x, SO_x and CO; H_2S and VOCs are typically associated with gas combustion and reciprocating engines. The emissions data provided by Africary indicated that H_2S and VOCs would not be present in the exhaust gases. These components were therefor excluded from the dispersion modelling simulations.

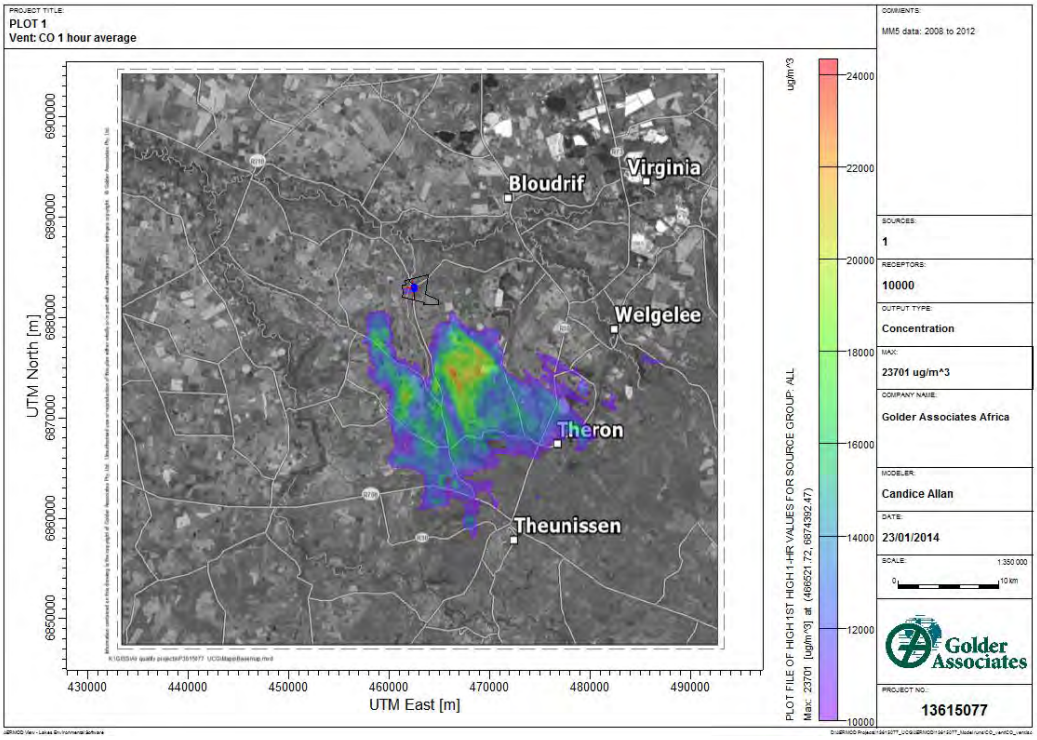


Figure 11-2: Simulated CO emissions during venting (1 hour average)

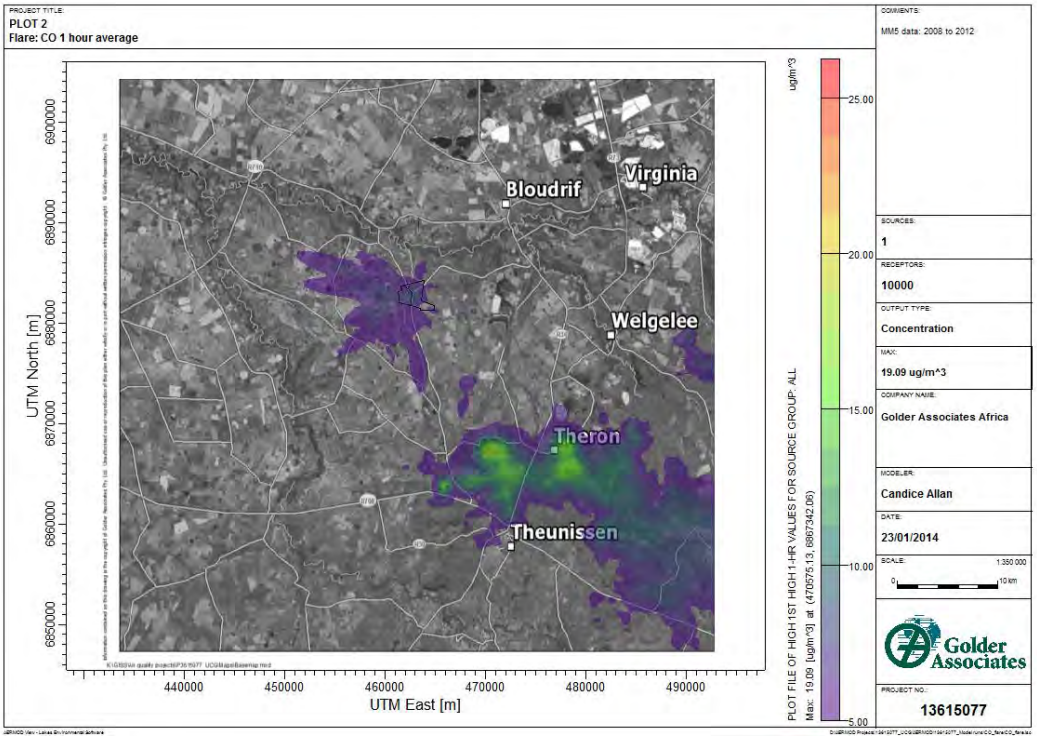


Figure 11-3: Simulated CO emissions during flaring (1 hour average)

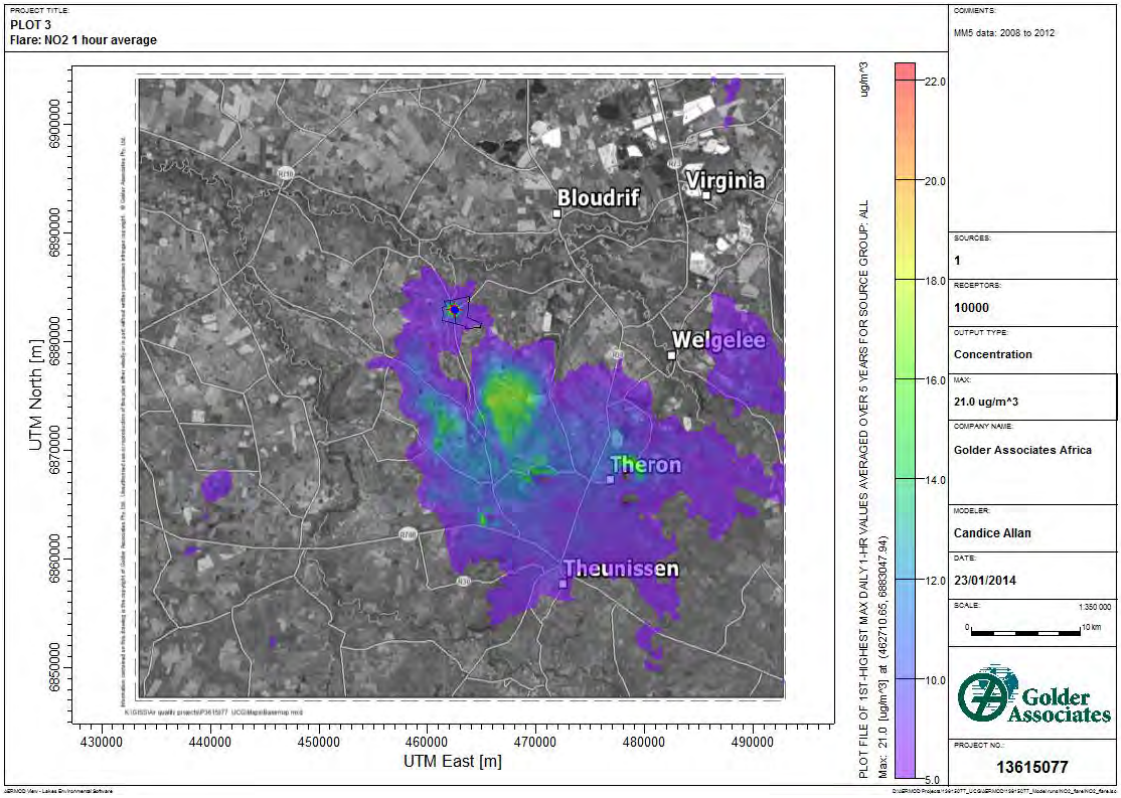


Figure 11-4: Simulated NO_x emissions during flaring (modelled as NO_2, 1 hour average)

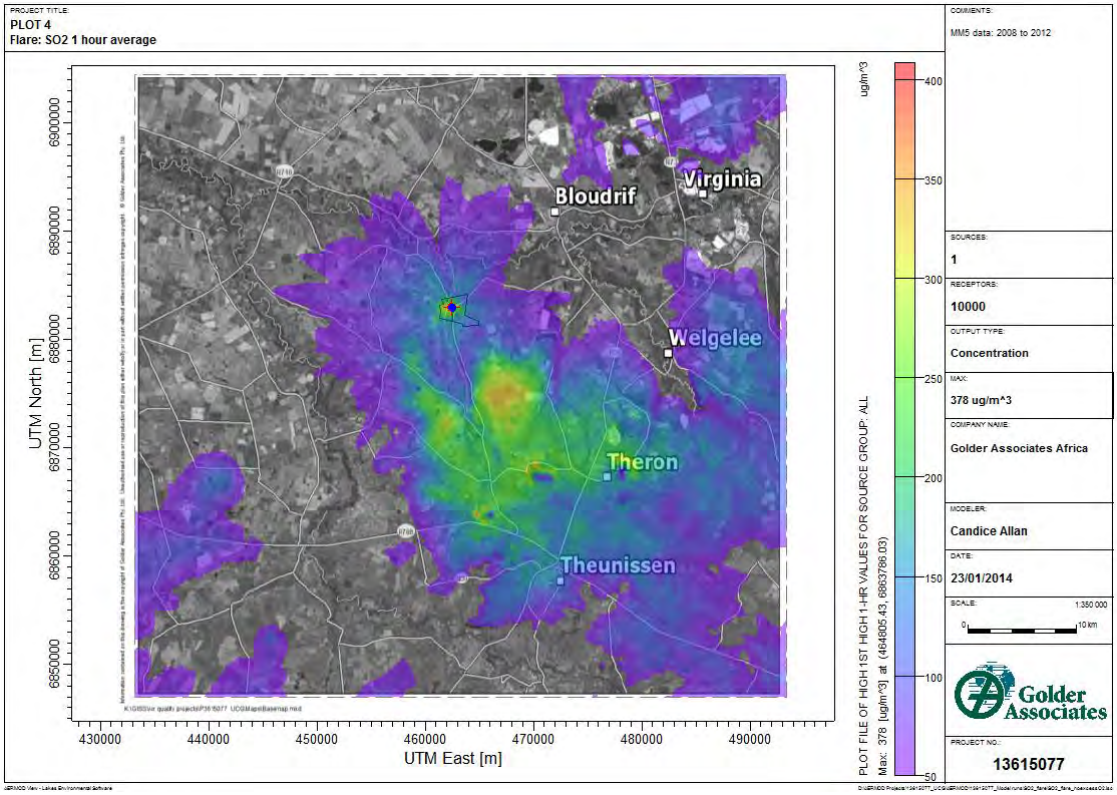


Figure 11-5: Simulated SO_2 emissions during flaring (1 hour average)

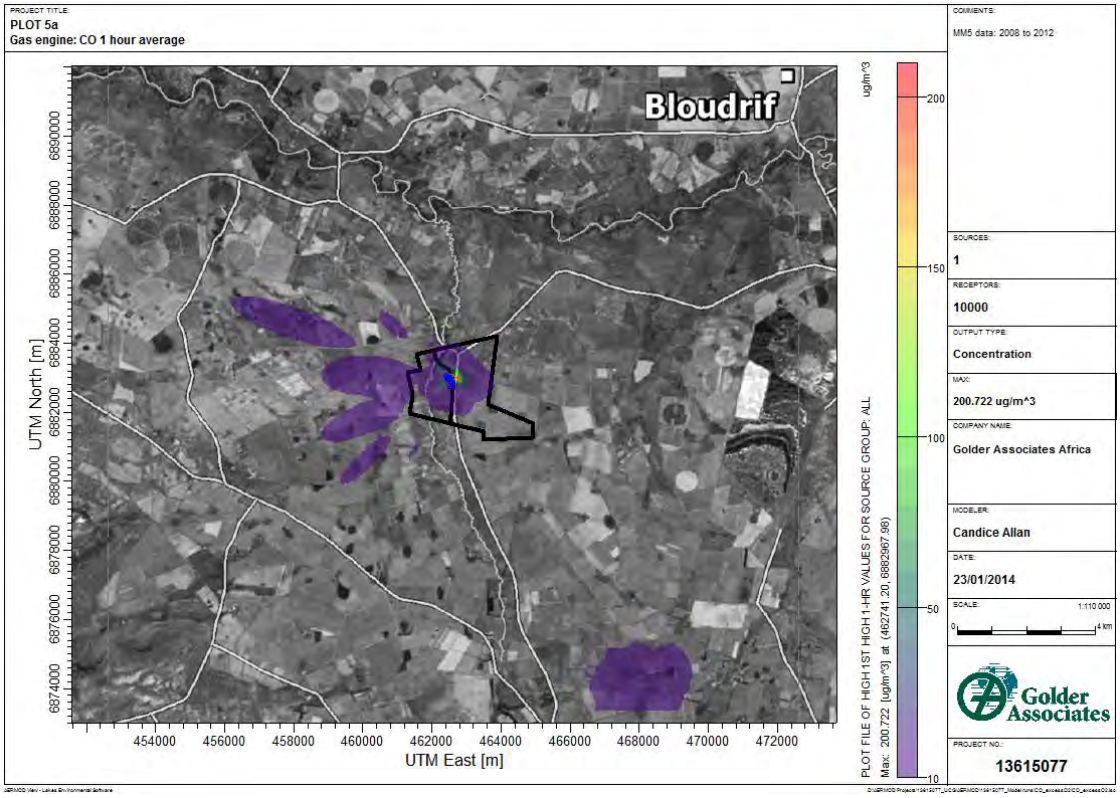


Figure 11-6: Simulated CO emissions released via the gas engine exhaust (1 hour average)

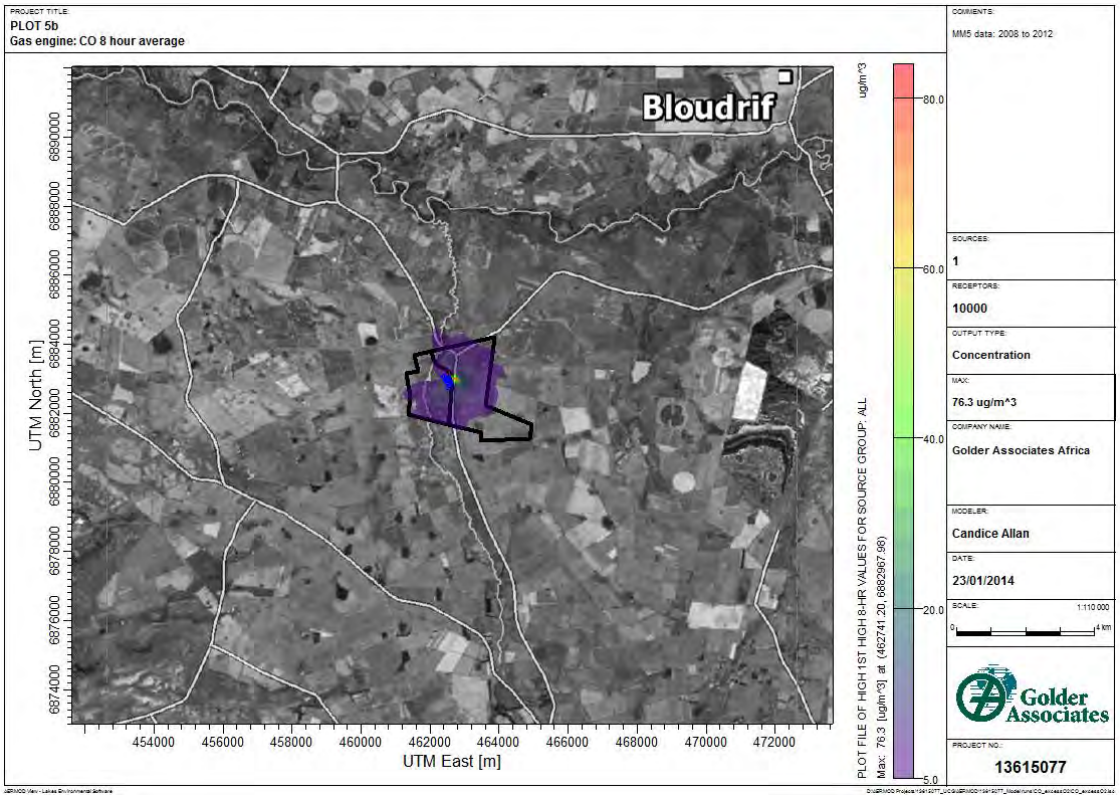


Figure 11-7: Simulated CO emissions released via the gas engine exhaust (8 hour average)

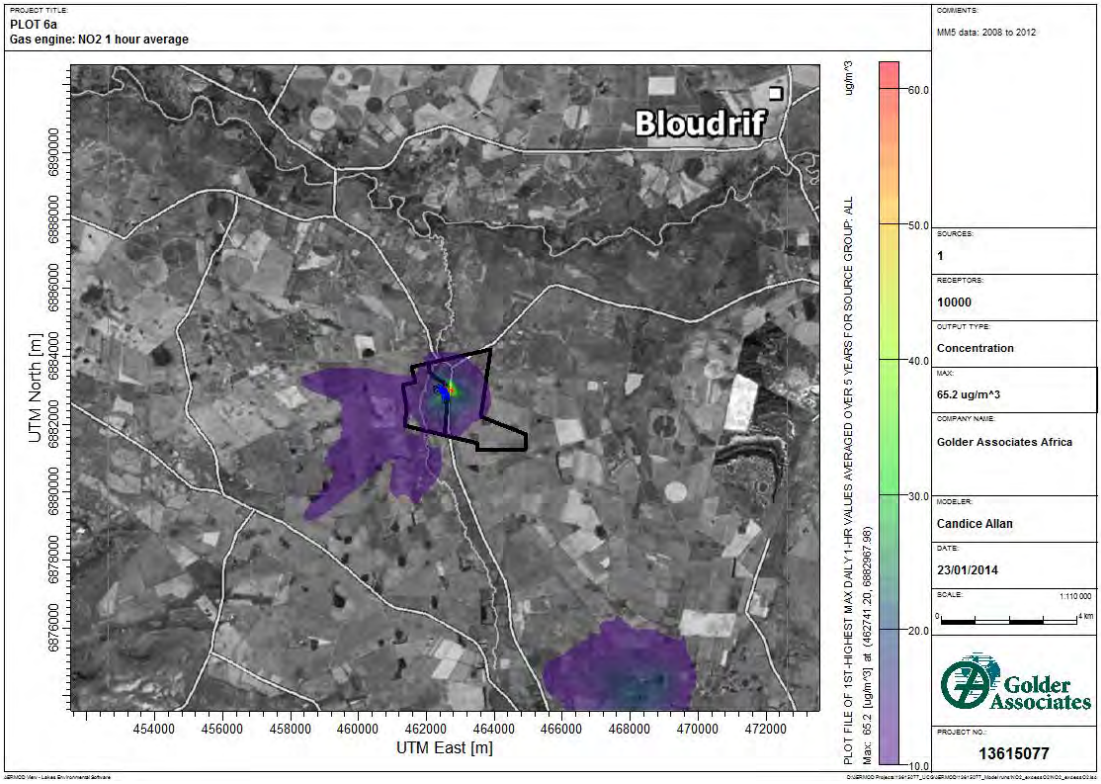


Figure 11-8: Simulated gas engine NO_x emissions at IFC standard of 32 g/s (modelled as NO_2, 1hour average)

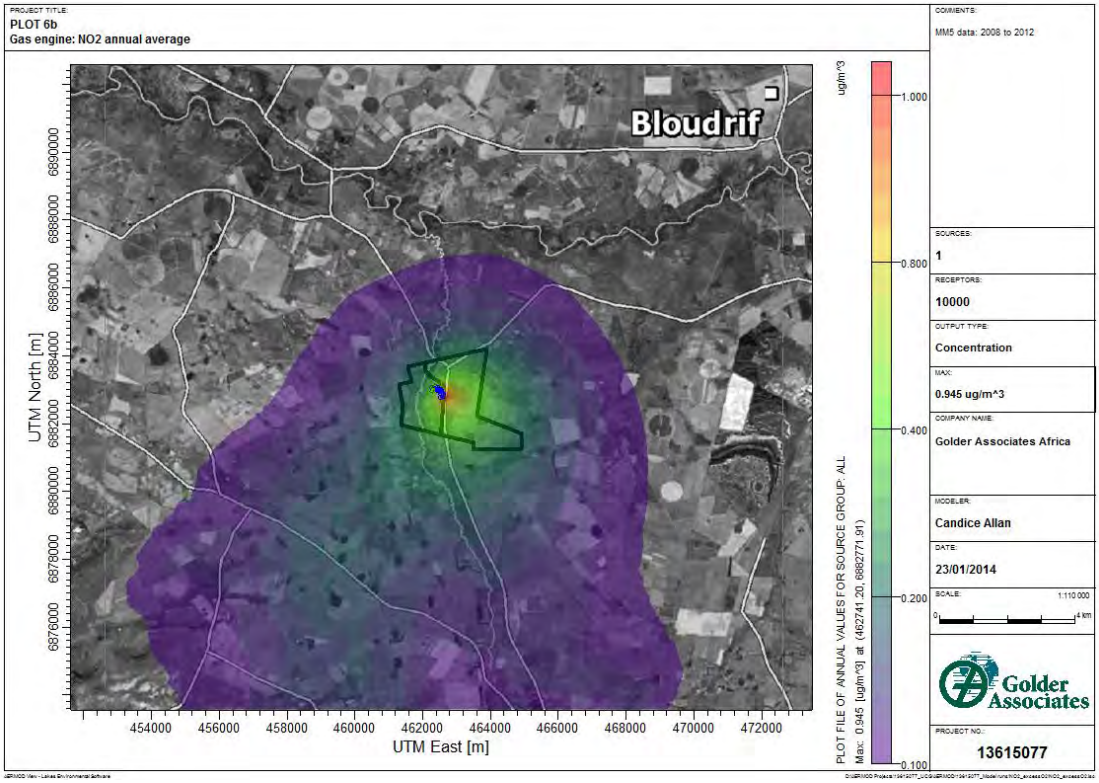


Figure 11-9: Simulated gas engine NOx emissions at the IFC standard of 32 g/s (modelled as NO_2, annual average)

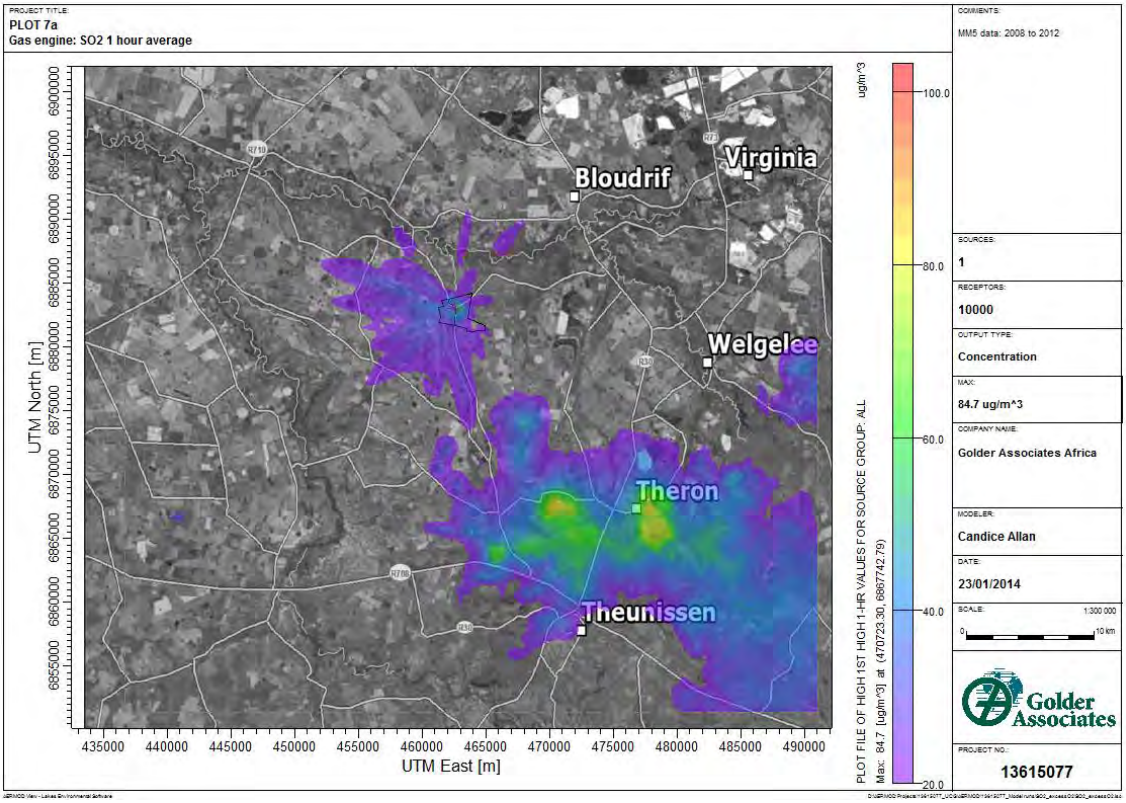


Figure 11-10: Simulated gas engine SO2 emissions simulation (1hour average)

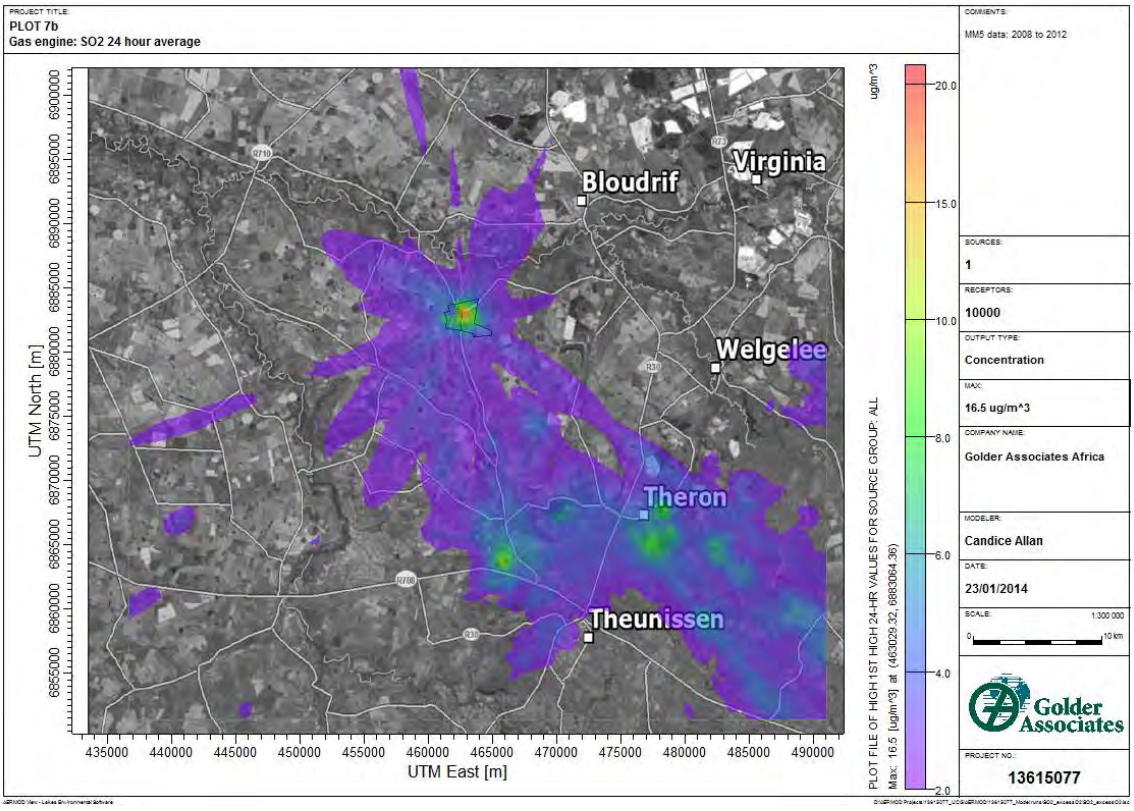


Figure 11-11: Simulated gas engine SO2 emissions simulation (24 hour average)

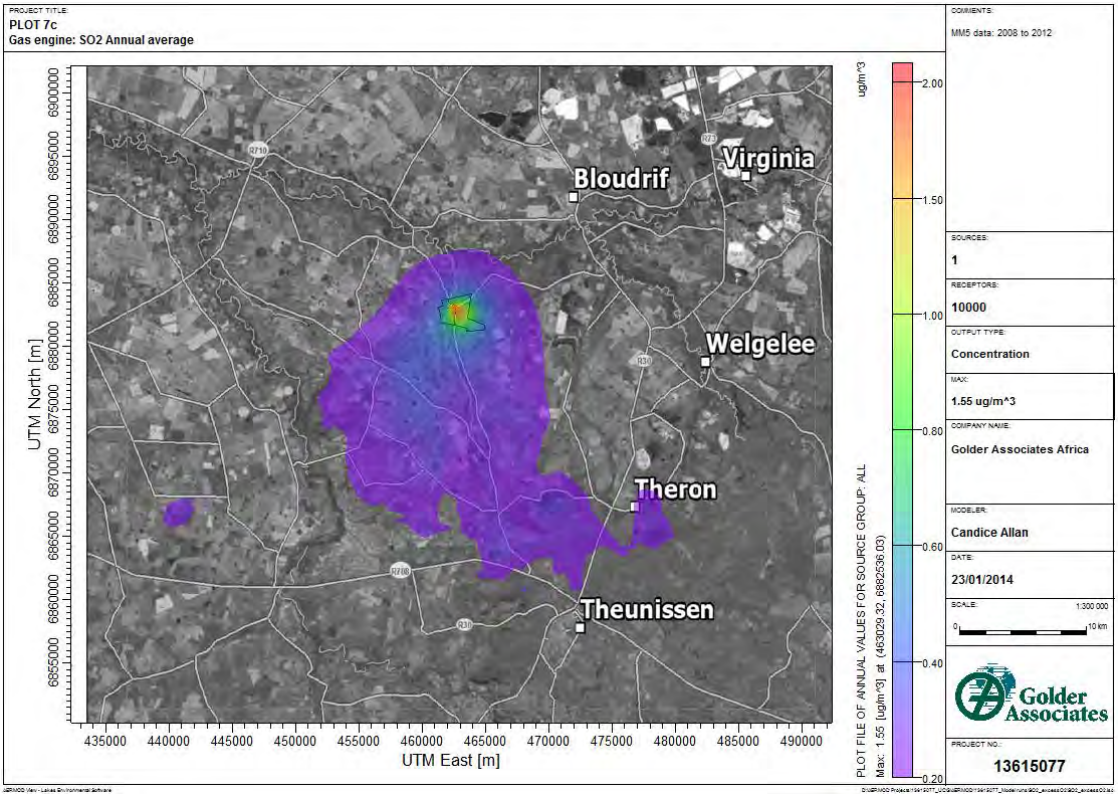


Figure 11-12: Simulated gas engine SO2 emissions simulation (annual average

11.1.6.2.2 Impacts and mitigation measures

From the dispersion modelling results summarised in Table 11-10 and illustrated in Figure 11-2 to Figure 11-12 it is evident that emissions from the power plant under normal operating conditions will not affect air quality in the region significantly, even at emission rates equivalent to the allowable rates in terms of the South African standards, which are much higher than the estimated emission rates (see sections 11.1.2.1 and 11.1.6).

The simulation results indicate that venting could raise ambient CO levels to 50% of the one-hour South African standard over a substantial area and up to 80% of the standard in a few small spots some 5 km to the south and south-south-east of the power plant site. They also indicate that flaring could raise ambient SO_2 levels to 50% of the one-hour South African standard over a fairly large area and up to 70% of the standard in a few small areas some 5 km to the south and south-south-east of the power plant site.

Venting and flaring are expected to be rare events of short duration.

Taking into consideration the existing, pre-project air quality in the area and the conservative approach followed in the dispersion modelling, the impact of the operational phase on the ambient air quality is assessed as being of ***moderate (SP = 45)*** significance, mainly because of the predicted impacts of venting and flaring. The impact can be reduced to one of ***moderate (SP = 36)*** significance by:

- Where possible, undertaking venting only when atmospheric conditions are conducive to efficient dispersion, e.g. during summer and when change of season winds are prevalent, and avoiding inversion conditions, i.e. during winter;
- Flaring only when absolutely necessary, and then limiting the duration as far as possible;
- Avoiding flaring at night if possible, especially during winter; and
- Cleaning of raw gas to remove particulate matter and higher hydrocarbons before the gas is used in the reciprocating engines;

Despite the low impacts indicated by dispersion modelling of normal operations, the following good practice measures are also recommended:

- The gas engine exhaust should have a height of at least 15m;
- Applying control technologies to the gas engine exhaust emissions, which may include:
  - Non Selective Catalytic Reduction (99.0% Reduction Efficiency for NO_x); and
  - Non Selective Catalytic Reduction (98.0% Reduction Efficiency for CO); or
  - Catalytic Oxidation (95.0% Reduction Efficiency for CO)
- Stack monitoring should be implemented. This should be in line with the AEL requirements to maintain control of the emissions within the specified levels.

11.1.6.3 Closure and rehabilitation

The activities described in section 10.1.3 will have similar impacts to those foreseen for the construction phase but of shorter duration. Once the rehabilitation work has been completed, monitoring and maintenance will continue for at least five years, but these activities will not have any significant impacts.

Without mitigation, the air quality impact during the closure and rehabilitation phase is assessed as being of ***moderate (SP = 50)*** significance.

The following mitigation measures are recommended:

- Wet suppression, applied sparingly, to ensure the absence of visible dust;
- Enforce low vehicle speeds on unpaved areas (≤ 30 km/h);
- Ensuring that all equipment is well maintained and in good working order;
- Switching equipment and vehicles off when not in use;
- Avoiding the use of unsealed roads where possible; and
- Re-vegetating the disturbed areas with a locally indigenous grass species as soon as possible.

Application of the recommended mitigation measures would reduce the impact to one of ***very low (SP = 10)*** significance.

11.2 Noise

11.2.1 Standards and guidelines

The time-varying characteristics of environmental noise are described using statistical noise descriptors:

- Leq: The Leq is the constant sound level that would contain the same acoustic energy as the varying sound level, during the same period of time;
- LMax: The instantaneous maximum noise level for a specified period of time; and
- LMin: The instantaneous minimum noise level for a specified period of time.

The following relationships occur for increases in A-weighted noise levels:

- The trained healthy human ear is able to discern changes in sound levels of 1 dBA under controlled conditions in an acoustic laboratory;
- It is widely accepted that the average healthy ear can barely perceive noise level changes of 3 dBA;
- A change in sound level of 5 dBA is a readily perceptible increase in noise level; and
- A 10-dBA change in the sound level is perceived as twice as loud as the original source.

The World Bank in its Environmental Health and Safety Regulations applies the following noise level guidelines:

- Residential area – 55 dBA for the daytime and 45 dBA for the nighttime period; and
- Industrial area – 70 dBA for the day- and nighttime periods.

Some of the noise levels that a person is exposed to on a daily basis in the work place and/or in the home environment are listed in Table 11-11.

Table 11-11: General noise levels of daily exposure

Activity	dBA
Whisper	30
Normal conversation	55 – 65
Shouted conversation	90
Baby crying	110
Computer	37 – 45
Radio playing in background	45 – 50
Microwave oven	55 – 60
Washing machine	50 – 75
Clothes dryer	56 – 58
Alarm clock	60 – 80
Television	70
Flush toilet	75 – 85
Ringing telephone	80
Hairdryer	80 – 95
Vacuum cleaner	84 – 89
Maximum output of stereo	100 – 110

In South Africa, the noise impact on human receptors is evaluated in terms of the SANS 10103 guidelines for sound pressure levels as listed in Table 11-12 and the typical responses as listed in Table 11-13.

Table 11-12: Noise level standards for various districts

Type of District	Equivalent continuous rating level $L_{Req.T}$ for ambient noise - dBA					
	Outdoors			Indoors with windows open		
	Day-night L_{Rdn}	Daytime L_{Rd}	Night time L_{Rn}	Day-night L_{Rdn}	Daytime L_{Rd}	Night time L_{Rn}
Rural districts	45	45	35	35	35	25
Suburban districts with little road traffic	50	50	40	40	40	30
Urban traffic	55	55	45	45	45	35
Urban districts with some workshops, business premises and main roads	60	60	50	50	50	40
Central business districts	65	65	55	55	55	45
Industrial districts	70	70	60	60	60	50

Daytime and night time refer to the hours from 06h00 - 22h00 and 22h00 - 06h00 respectively.

Table 11-13; Typical community response to increase in ambient noise level

Excess $L_{Req.T}$ dBA	Response
0 - 2	Little or no reaction
2 - 10	Sporadic complaints
5 - 15	Widespread complaints
10 - 20	Threats of community/group action
>15	Vigorous community/group action

Excess $L_{Req.T}$ is calculated from the appropriate of the following:

a) Excess $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation *minus* $L_{Req,T}$ of the residual noise (determined in the absence of the specific noise under investigation).

b) Excess $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation *minus* the typical rating level for the applicable district as determined from Table 11-12

11.2.2 Assessment of noise impact

The noise impact assessment was undertaken by dBAcoustics (van der Merwe, B;, December 2013).The predicted noise impacts during the various phases of the project are as discussed below.

11.2.2.1 Construction

Noise levels for typical construction equipment that would be used at the project site and the noise attenuation with distance are shown in Table 11-14.

Table 11-14: Sound pressure levels of construction machinery

Equipment	Line-of-Sight Estimated Noise Level Attenuation - dBA						
	5m	30m	60m	120m	240m	480m	960m
Dump truck	91	61.3	55.2	49.1	43.1	34.9	26.6
Backhoe	85	55.3	49.3	43.3	37.3	29.1	20.8
Flatbed truck	85	55.3	49.3	43.3	37.3	29.1	20.8
Pickup truck	70	40.3	34.3	27.3	21.3	15.3	9.3
Tractor trailer	85	55.3	49.3	43.3	37.3	29.1	20.8
Crane	85	55.3	49.3	43.3	37.3	29.1	20.8
Pumps	70	40.3	34.3	27.3	21.3	15.3	9.3
Welding Machine	72	42.3	36.3	29.3	23.3	18.3	12.3
Generator	90	61.3	55.2	49.1	43.1	34.9	26.6
Compressor	85	55.3	49.3	43.3	37.3	29.1	20.8
Jackhammer	90	61.3	55.2	49.1	43.1	34.9	26.6
Pneumatic tools	85	55.3	49.3	43.3	37.3	29.1	20.8
Excavator	90	61.3	55.2	49.1	43.1	34.9	26.6
Grader 140H	91.0	61.3	55.2	49.1	43.1	34.9	26.6
TLB	92.0	61.3	55.2	49.1	43.1	34.9	26.6

The above noise levels represent the maximum levels that will be generated during the construction of the plant and infrastructure. For health and safety reasons all operators of dozers, graders, jackhammers and jumping jack compactors and all personnel working in areas where the noise level exceeds 85 dBA must wear hearing protection.

The highest noise level at 960m from the construction site due to any one of the noisiest machines will be 26.6dBA. The cumulative noise level when the four noisiest machines are operating simultaneously will be 30.6dBA. Noise increases at the noise sensitive areas (NSAs) shown on Figure 7-7 will occur intermittently during the construction phase, which is expected to last for about 12 to 15 months.

See Table 11-15 for the distance from the power plant site to each of the NSAs shown on Figure 7-7. The direction is also listed because of the effect of wind direction on noise propagation. The average annual wind rose for the area is shown in Figure 7-4.

Table 11-15: Distance of noise sensitive areas from power plant site

Noise sensitive area	Distance from site in metres	Direction from site
NSA1	1 320	North
NSA 2	4 000	West
NSA 3	3 925	West
NSA 4	3 110	South
NSA 5	4 050	East
NSA 6	4 040	East
NSA 7	2 230	East
NSA 8	4 320	East

From Table 11-12 (noise level standards), Table 11-14 (attenuation of sound pressure levels of construction machinery with distance), Table 11-15 (distance of NSAs from the power plant site) and Table 7-5 (existing noise levels at the NSAs), it is evident that the construction noise output is unlikely to reach intrusive levels at any of the NSAs. The impact on the public will also be limited by the relatively short duration of the construction period. However, the construction workers will be exposed to relatively high noise levels. Taking all of the contributing factors into consideration, the noise impact during construction is rated as being of ***moderate (SP = 32)*** significance.

The following mitigation measures are recommended:

- Selecting equipment with lower sound power levels;
- Installing silencers for fans;
- Installing suitable mufflers on engine exhausts and compressor components; and
- Installing acoustic enclosures for equipment causing radiating noise; and
- Mandatory wearing of hearing protection equipment in areas where noise levels are ≥ 85 dBA.

Application of the recommended mitigation measures are predicted to reduce the noise impact to a level of ***low (SP = 18)*** significance.

11.2.2.2 Operation

Noise propagation contours were calculated for both power generation alternatives discussed in section 5.3, namely gas turbines and gas engines, by mathematical modelling. Other contributors to noise output from the plant site that are common to both alternatives are the following:

- Gas flare – 90.0dBA;
- Steam plant – 90.0dBA; and
- Trucks entering and leaving the property – 80.0dBA.

The operation of two gas turbines to produce 50 - 60 MWe would generate a sound pressure level of about 133 dBA, which can be reduced to about 100 dBA by enclosing the turbines in an acoustically designed brick

and mortar building with a flat concrete roof. The building will have sound-absorbing interior cladding and tight-fitting acoustic doors, but no windows.

The cumulative noise level due to all of the above sources will be 100.5dBA.

The operation of 18 Deutz gas engines (TCG 2032 V12) in series would generate 137 dBA. The engines will be fitted with exhaust mufflers and they will be housed in an acoustically designed brick and mortar building as described above, but fitted with 3 - 4 metre long vertical acoustic louvres. These measures will result in an estimated noise level of 83.4 dBA on the outside of the building.

The cumulative noise level for a plant based on gas engines as described above will be 94.5 dBA.

The following equation was used to calculate the noise propagation contours:

$L_R = SPL - 20\log(R) - \alpha_a$

Where:

L_R = Sound pressure level at a distance from the source;

SPL = Sound pressure level at the source;

R = Distance from the source; and

αa = Sound reduction due ground conditions and trees and distance from the source. An average value of 5.0dB was used according to BS5228:Part1(1997).

The calculated noise contours for the gas turbine alternative are shown in Figure 11-13 and listed in Table 11-16, which also lists the noise intrusion levels.

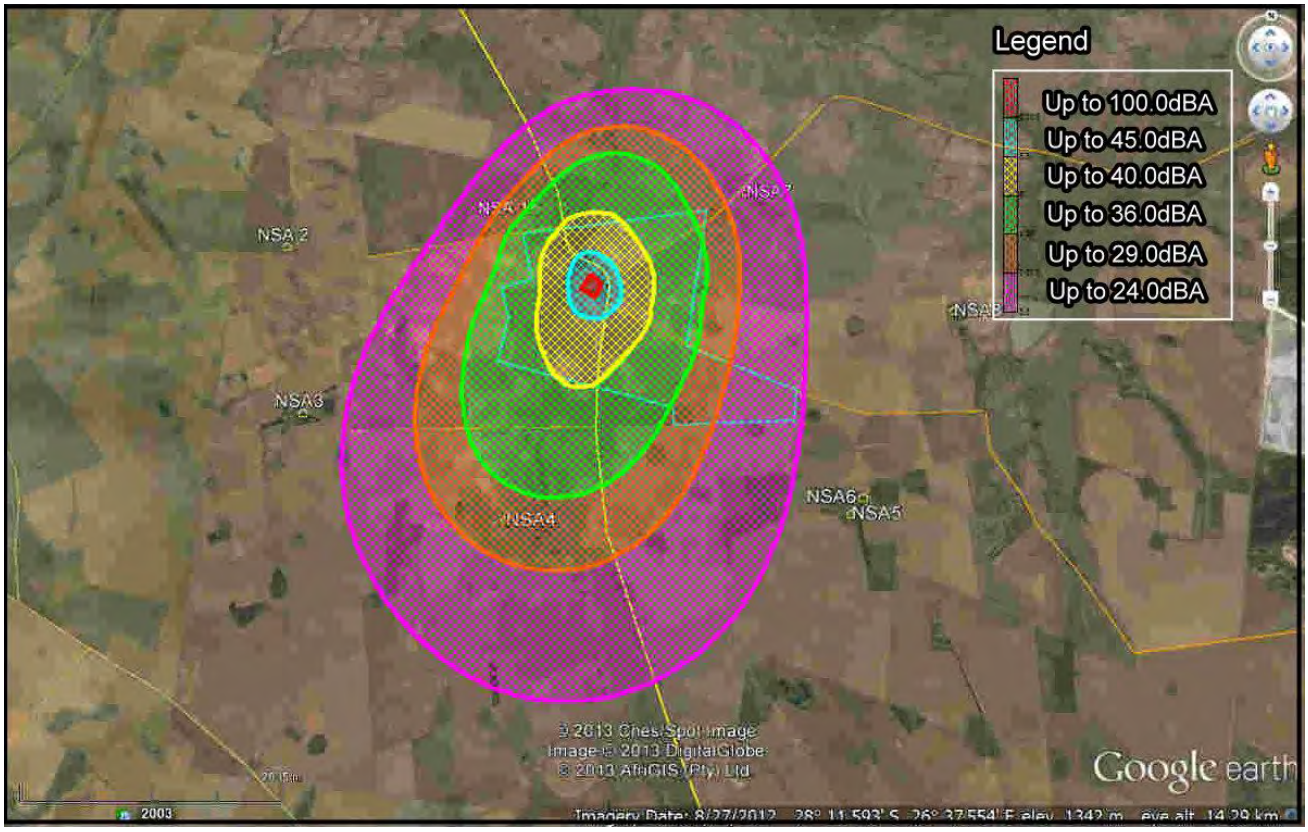


Figure 11-13: Calculated noise contours for power plant based on gas turbines

Table 11-16: Calculated noise levels at NSAs – gas turbine alternative

NSA	Cumulative daytime noise level at NSA - dBA (calculated noise level + prevailing ambient noise level)	Cumulative night time noise level at NSA - dBA (calculated noise level + prevailing ambient noise level)	Prevailing ambient noise level during daytime - dBA	Prevailing ambient noise level during night time - dBA	Daytime noise intrusion level - dBA	Night time noise intrusion level- dBA
1	39.8	38.1	37.9	27.2	1.7	10.9
2	36.1	28.7	35.8	27.0	0.3	1.7
3	32.9	28.6	32.3	26.7	0.6	1.9
4	31.2	30.7	29.7	28.9	1.5	1.8
5	31.6	29.3	30.8	27.9	0.8	1.4
6	31.6	29.3	30.8	27.9	0.8	1.4
7	34.1	30.7	32.5	26.1	1.6	4.6
8	34.1	28.9	30.7	27.5	3.4	3.2

From Table 11-13 and Table 11-16 it is evident that the gas turbine plant will be audible at all the NSAs, may lead to complaints from residents at NSA 7 and 8, and is likely to be experienced as unacceptably intrusive by residents at NSA1.

The noise impact of a 50 MWe plant operating on two gas turbines that are enclosed in an acoustic brick and mortar building, with *ca.* 100 mm thick walls and a flat 100 mm thick concrete roof, is assessed as being of ***high (SP = 85)*** significance.

The calculated noise contours for the gas engine alternative are shown in Figure 11-14 and listed in Table 11-17, which also lists the noise intrusion levels.

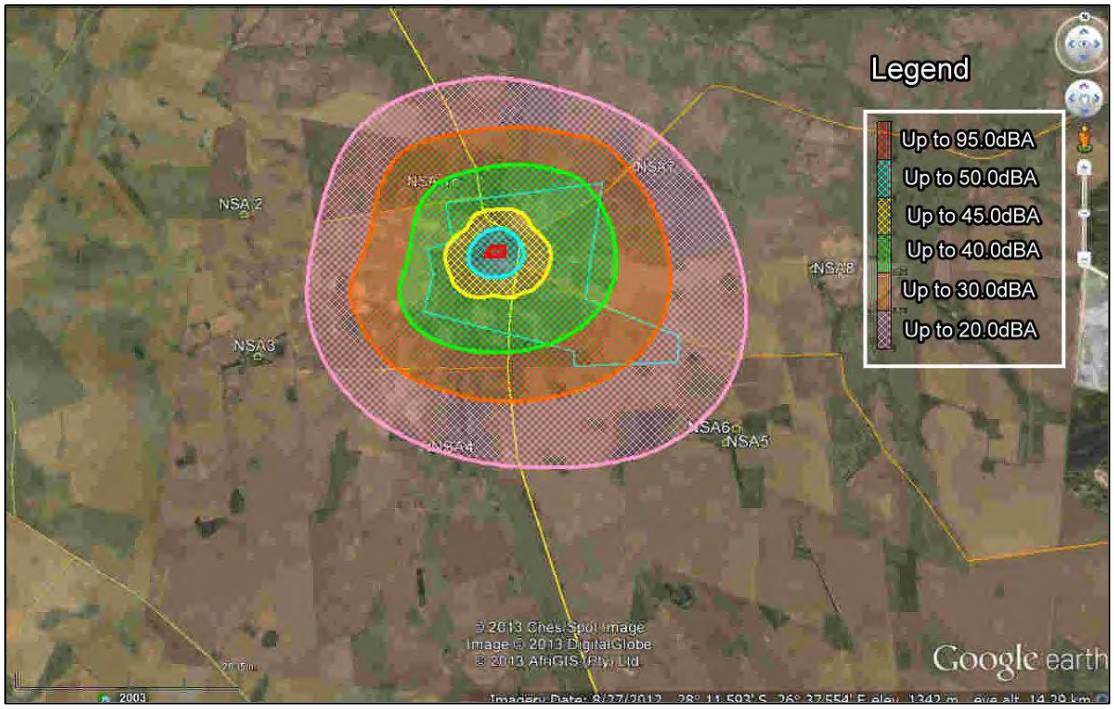


Figure 11-14: Calculated noise contours for power plant based on gas engines

Table 11-17: Calculated noise levels at NSAs – gas engine alternative

NSA	Cumulative daytime noise level at NSA -dBA (calculated noise level + prevailing ambient noise level)	Cumulative night time noise level at NSA - dBA (calculated noise level + prevailing ambient noise level)	Prevailing ambient noise level during daytime - dBA	Prevailing ambient noise level during night time - dBA	Daytime noise intrusion level - dBA	Night time noise intrusion level- dBA
1	38.2	30.2	37.9	27.2	0.5	5.0
2	35.9	27.5	35.8	27.0	0.1	0.5
3	32.4	27.2	32.3	26.7	0.1	0.5
4	30.1	29.4	29.7	28.9	0.4	0.5
5	31.0	28.3	30.8	27.9	0.2	0.4
6	31.0	28.3	30.8	27.9	0.2	0.4
7	32.9	27.7	32.5	26.1	0.4	1.6
8	30.9	27.9	30.7	27.5	0.2	0.4

From Table 11-13 and Table 11-17 it is evident that the gas turbine plant will be audible at all the NSAs, but is unlikely to be experienced as sufficiently intrusive to lead to complaints from residents at NSAs 2 to 8. Residents at NSA 1 may experience the noise as unacceptable during the night.

Reducing the noise level generated by the power plant from 100.5 to 94.5 dBA by opting for gas engines would result in only NSA1 being exposed to an intrusive noise level, which would reduce the assessed impact to one of ***moderate (SP = 55)*** significance.

The recommended mitigation measures are therefore as follows:

- Use of gas engines instead of gas turbines;
- Selecting engines with lower sound output levels and equipped with appropriate exhaust mufflers;
- Enclosing of the engines in a building that has been properly designed and built to reduce the level of noise at source;
- Mandatory wearing of hearing protection equipment in areas where noise levels are ≥ 85 dBA.
- Planting a screen of fast-growing indigenous trees and other vegetation around the perimeter of the site, especially on the north-western side;
- Creating and maintaining a communication channel (name, phone and fax number, e-mail) that members of the public can use to lodge complaints, pose questions and ask for information; and
- Creating and maintaining a complaints register, following up on every complaint and giving responses until the complaint is closed out.

Note: *It would be possible to reduce the noise from a gas turbine-based power plant to levels similar to those indicated in this report for gas engines by installing more acoustic screening measures at additional cost.*

11.2.2.3 Closure and rehabilitation

The activities undertaken during the closure and rehabilitation phase will be similar to those of the construction phase, but of shorter duration and lesser extent, involving fewer vehicles and machines. The noise impact on the public will be limited by the relatively short duration of the closure and rehabilitation

phase, attenuation due to distance and the then existing noise levels at the NSAs. However, the workers may be exposed to relatively high noise levels. After 3 to 4 months, when occasional site visits by light utility vehicles will be undertaken for monitoring and maintenance purposes, the noise emanating from the site will be greatly reduced.

Taking all of the contributing factors into consideration, the noise impact during closure and rehabilitation is rated as being of ***moderate (SP = 32)*** significance.

The following mitigation measures are recommended to reduce the noise impact to a level of ***low (SP = 12)*** significance:

- Selecting equipment with lower sound power levels;
- Installing silencers for fans;
- Installing suitable mufflers on engine exhausts and compressor components; and
- Using acoustic enclosures for equipment causing radiating noise; and
- Mandatory wearing of hearing protection equipment in areas where noise levels are ≥ 85 dBA.

11.3 Topography

11.3.1 Construction

The earthmoving operations described in section 10.1.1 will result in minor changes in the local topography, associated mainly with the excavation of basins for the brine ponds, and the erection of buildings and a storm water diversion berm. These changes will be confined to the power plant site. They will be reversible and it is improbable that they would be viewed as significant. The establishment of the injection and production wells and the transmission lines will have no effect on the pre-existing topography.

Accordingly, the significance of topographical changes is rated as being of ***low (SP = 14)*** significance. No mitigation measures are necessary.

11.3.2 Operation

As discussed in section 2.5.2 of this report, goafing will take place after the coal in the underground seam has been consumed and as indicated in section 5.9, this can lead to surface subsidence directly above the gasification area. Due to the relation between the depth of the coal seam below the surface (more than 300 m), its thickness (about 3.2 m) and the nature of the overlying rock, surface subsidence of 1.0 to 1.2 is likely to occur. The area is currently used for grazing and it will remain fit for such use. Accordingly, the potential impact has been assessed as being of ***very low (SP = 7)*** significance. It is not expected that any mitigation measures would be required.

11.3.3 Closure and rehabilitation

Removal of infrastructure, in-filling of the brine pond basins and landscaping to restore original drainage lines will return the topography at the site to its original state. Surface subsidence due to goafing may be expected, but it is unlikely to be significant. The potential impact is rated as being of ***very low (SP = 7)*** significance. It is not expected that any mitigation measures would be required.

11.4 Geology

11.4.1 Construction

The construction activities described in section 10.1.1 will cause only minor disturbance of the near-surface geology and lithology. Drilling of the injection and production wells will take place through all the strata down to about 350 metres, but the geological disturbance will not extend beyond the diameter of each borehole. The impact is assessed as being of ***low (SP = 12)*** significance. No mitigation is possible.

11.4.2 Operation

The consumption of the coal in the seam will alter the geology permanently and irreversibly within each underground gasifier, resulting in a localised geological impact of ***high (SP = 85)*** significance, which cannot be mitigated.

11.4.3 Closure and rehabilitation

The closure and rehabilitation phase will not have any effect on the geology of the area ***(SP = 0)***.

11.5 Soils, land capability and land use

11.5.1 Construction

During the construction operations described in section 10.1.1, topsoil will be stripped from the relatively small area where infrastructure will be erected on the power plant site. The topsoil will be stockpiled for use in the rehabilitation phase. The soils on the plant site and along the preferred power line and pipeline route are erosion sensitive and the potential for loss of topsoil is high. Potential impacts on the topsoil are:

- Degradation of quality due to mixing with subsoil when excavating foundation trenches and the basins for the brine ponds;
- Loss of topsoil due to water and wind erosion, both at the power plant site and along the power line and pipeline route;
- Contamination with hydrocarbons, hydraulic fluids, cement, paint and solvents; and
- Colonisation of the stockpile and disturbed areas along the power line and pipeline route by weeds.

The impact is rated as being of ***moderate (SP = 45)*** significance and it can be mitigated to ***low (SP = 21)*** significance by:

- Careful stripping and stockpiling to avoid mixing topsoil and subsoil as far as possible;
- Using as much of the topsoil as possible in the construction of the clean runoff diversion berm and stockpiling the rest;
- Limiting the stockpile height to 3 metres and the slope to 1 in 4, and rounding the top edges;
- Keeping the stockpile and diversion berm moist;
- Vegetating the stockpile and diversion berm with locally indigenous grass species;
- Immediate re-vegetation of disturbed soil along the power line and pipeline route; and
- Regular weeding of the stockpile, the berm and the power line and pipeline route.

11.5.2 Operation

The operational phase will not involve any further disturbance of the soil, but there will be a potential for soil pollution due to spillages of hydrocarbons, hydraulic fluids, brine and process chemicals, which is assessed as being of ***moderate (SP = 52)*** significance.

The following mitigation measures are recommended to reduce the impact to one of ***low (SP = 14)*** significance:

- All hydrocarbons, hydraulic fluids and liquid process chemicals should be stored in bunded areas, each of which has the capacity to contain the contents of the largest vessel within the bund plus ten per cent;
- All machinery to be serviced in workshops or *in-situ* in the power plant;
- Vehicles should be parked and washed on impervious surfaces that drain into the dirty water collection system;
- Paint, cleaning fluids and solid process chemicals should be stored in buildings with concrete floors and access control; and
- All spillages should be cleaned up immediately.

11.5.3 Closure and rehabilitation

Unless due care is taken with the placement of topsoil during closure and rehabilitation of the brine ponds, significant loss of soil quality may occur as a result of mixing with subsoil and overburden, contamination with hydrocarbons and hydraulic fluids, erosion and weed infestation, resulting in a long term impact, which is rated as being of ***moderate (SP = 60)*** significance, but only because the areas are small. The following mitigation measures should be applied to reduce the impact to one of ***low (SP = 16)*** significance:

- The basins should be filled with subsoil and profiled to promote free draining;
- The topsoil should be spread over the subsoil;
- Use light agricultural machinery and avoid compaction of the topsoil;
- Sample and analyse the soil after placement and add nutrients (compost and fertiliser) as advised by a qualified agronomist;
- Revegetate with locally indigenous grass, forb, shrub and tree species under the direction of a qualified botanist; and
- Monitor rehabilitation progress three-monthly until the vegetation becomes self-sustaining. Repair any erosion rills that may have developed and, if any bare patches larger than 4 m^2 are found, they should be re-vegetated after investigating the reasons and taking remedial action.

11.6 Surface water

A site water balance and storm water management plan were developed as part of the project-specific surface water study (Cassa, A; Coleman, T;, February 2014). The site layout as shown in Figure 2-7 is designed to have minimal infrastructure which is all enclosed and bunded.

Due to the Africary site's minimal layout and the potentially polluted areas being bunded to capture the 50 year 24 hour storm depth, the stormwater from the remainder of the site is considered to be clean and it only needs to be diverted away from the site towards the Palmietkuilspruit. The stormwater management system has been designed so that rainwater captured in the bunded areas is pumped into the plant water circuits for re-use. A pollution control dam is not considered to be necessary.

11.6.1 Proposed stormwater management plan

The clean and dirty water sub-catchments and the proposed stormwater management strategy are shown in Figure 11-15 as follows:

- The runoff generated east of the main road (S1_5, S1_6 and S1_7) will be diverted by cut-off trenches (C1, C2 and C5) running alongside the main road around the site. The water will then be allowed to drain freely towards the Palmietkuilspruit from outfall Out_1;
- The runoff generated from the south of the site (S1_4 and S1_3) will be diverted in channels C7 and C9 towards the Palmietkuilspruit;
- The water generated in the area of the oxygen plant will be diverted into rectangular channels running along the internal roads of the site and diverted around the farm house to the west of the site and allowed to drain towards the Palmietkuilspruit; and
- The water generated in the area of the cooling engines will be diverted into rectangular channels running along the internal roads of the site and diverted around the farm house to the west of the site and allowed to drain towards the Palmietkuilspruit.

Table 11-18: Catchment areas, slopes and computed runoff volume and flood peaks for the 50 year storm

Name	Area (ha)	% Slope (%)	24h storm depth (mm)	Total Runoff Volume per 24 hours (Megaliters)	Peak Runoff (m^3/s)	Clean / Dirty
S1_1	0.892	0.026	135.19	0.35	0.11	Clean
S1_2	0.933	0.027	135.19	0.37	0.12	Clean
S1_3	138.8	0.036	135.19	10.89	1.68	Clean
S1_4	686.6	0.017	135.19	18.61	2.63	Clean
S1_5	8.783	0.021	135.19	0.58	0.09	Clean
S1_6	44.9	0.011	135.19	1.13	0.16	Clean
S1_7	86.3	0.013	135.19	2.5	0.35	Clean
S1_8	1.309	0.046	135.19	0.53	0.19	Clean

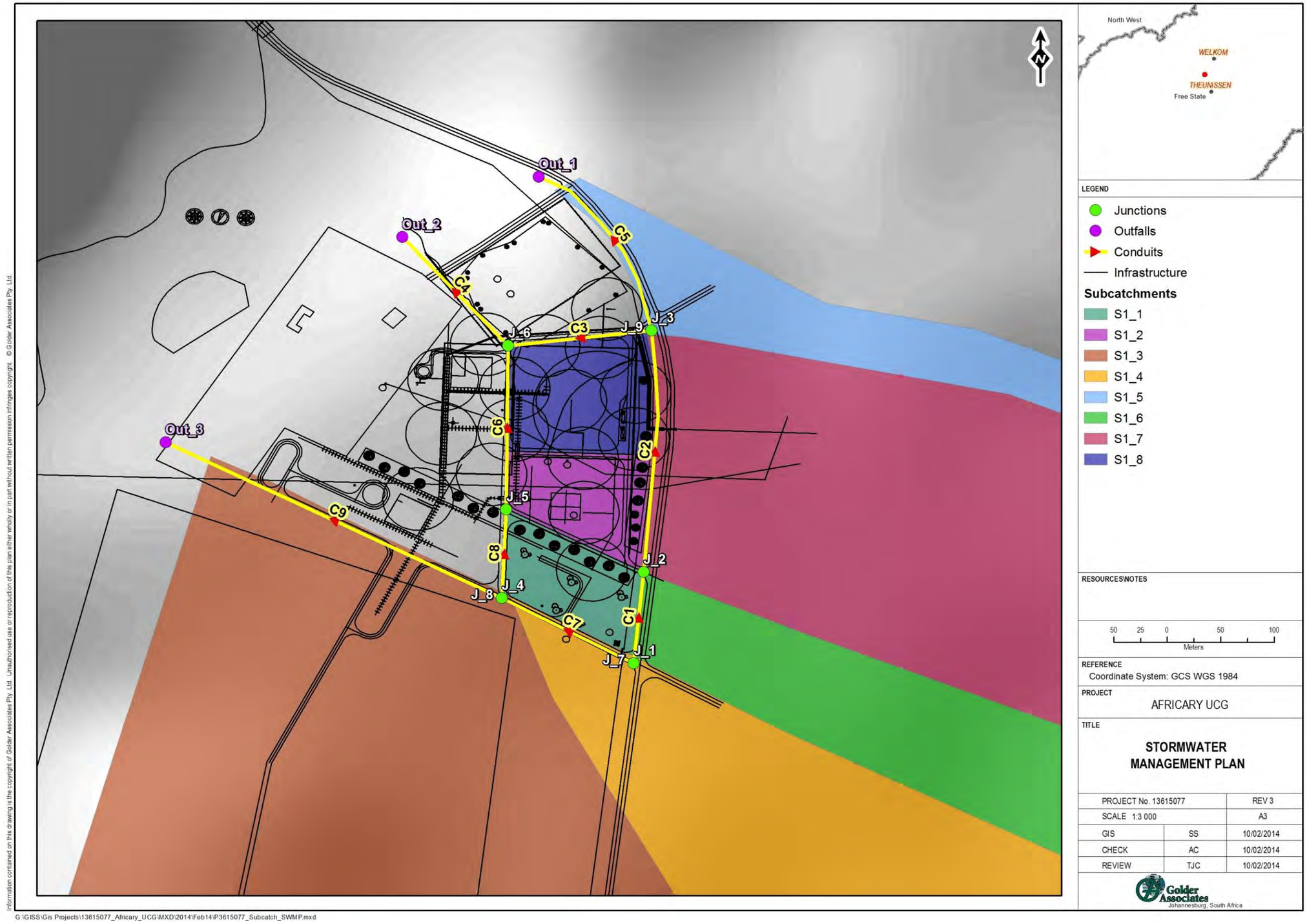


Figure 11-15: Proposed stormwater management system layout

11.6.1 Modelling the Stormwater Management System

The PCSWMM model was used as the flood analysis model. PCSWMM is a dynamic rainfall-runoff simulation model used for single event or long-term simulation of runoff quantity. This model was set up for the site and used to size the conveyance structures for separation of clean and dirty stormwater runoff.

The parameters used to model the overland and channel flow, including catchment areas and slopes together with the total runoff volume and the flood peaks for the 50 year storm event, are presented in Table 11-18. The Manning's 'n' coefficient used in the model for the impervious areas and pervious areas was 0.015 and 0.15 respectively.

The soils were identified as being in the sandy loam group. The model uses these criteria to incorporate infiltration into the analysis using the Green-Ampt infiltration method. The infiltration parameters for the clayey loam soil group are a suction head of 110.1 mm, a hydraulic conductivity of 21.8 mm/h and an initial soil moisture deficit of 0.25. Due to the area being mainly agricultural all the sub-catchments are 100% pervious.

11.6.2 Channel characteristics

All diversion channels have been sized to convey the 50 year return period flood peak as per Regulation 704 of the National Water Act. The proposed clean water diversion channel layout is shown in Figure 11-15. The Manning's roughness assumed for the channels was 0.035 (Vegetation lined channels) (Webber, 1971). The dimensions of the trapezoidal and rectangular channels required to convey the 50 year recurrence interval flood peak, the channel slope and the maximum velocity are listed in Table 11-19. A freeboard of 0.3 m under flood conditions was included in the channel height.

Table 11-19: Dimensions of clean runoff diversion channels to convey the 1:50 year flood peak

Name	Length (m)	Roughness	Material	Cross-Section	Height (m)	Bottom Width (m)	Left Slope	Right Slope	Channel Slope (m/m)	Maximum velocity (m/s)
C1	85.18	0.035	Earth	Trapezoid	1	1	1	1	0.01	0.76
C2	225.86	0.035	Earth	Trapezoid	1	1	1	1	0.01	1.09
C3	119.11	0.035	Earth	Rectangular	1	1	0	0	0.01	0.83
C4	133.72	0.035	Earth	Rectangular	1	1	0	0	0.01	1.05
C5	178.01	0.035	Earth	Trapezoid	1	1	1	1	0.01	1.14
C6	152.46	0.035	Earth	Rectangular	1	1	0	0	0.0143	1.01
C7	124.49	0.035	Earth	Trapezoid	1	1.5	1.5	1.5	0.01	1.61
C8	82.5	0.035	Earth	Trapezoid	1	1	1	1	0.0107	0.7
C9	312.97	0.035	Earth	Trapezoid	1.2	1.5	1.5	1.5	0.01	1.84

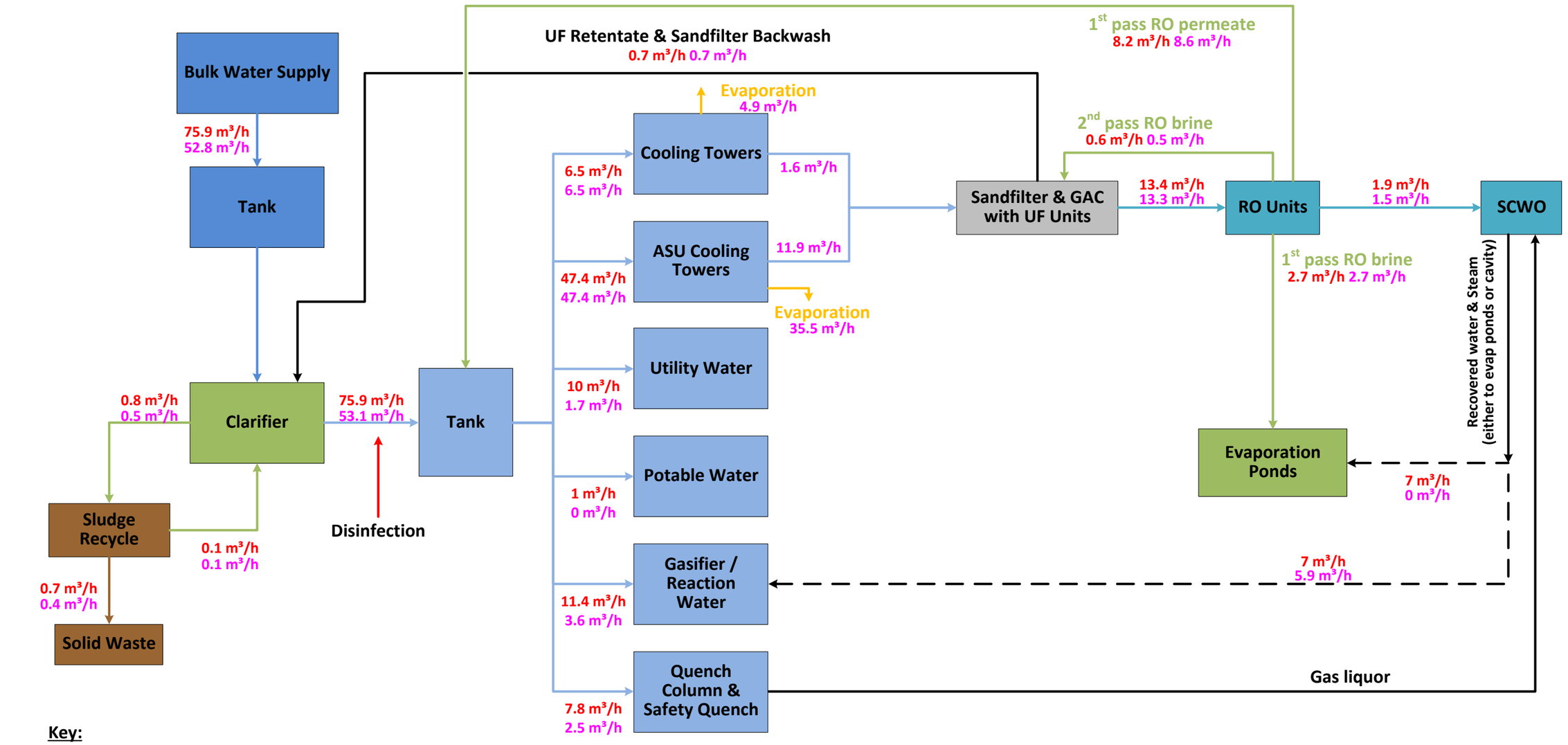
11.6.3 Water schematic

The water system at Africary plant will consist of a bunded area containing the cooling towers, tanks, a clarifier, quench columns, sand filters, reverse osmosis units and brine evaporation ponds.

The water circuit consists of the following:

- **Bulk water supply:** The bulk water supply for the gasification process will come from the Sand-Vet Water Users Association;
- **Storage tank:** The bulk water supply system will include a tank with a capacity of 2 500 m³ to provide contingency storage. This tank will supply the plant *via* the clarifier;

- **Clarifier:** The clarifier will receive raw water from the storage tank. It will also receive water and sludge from the ultrafiltration (UF) and sand filter backwash and granular activated carbon (GAC) units. The sludge will settle out in the clarifier and the clear supernatant water will be disinfected and pumped to the clean water tank;
- **Sludge Filter:** A filter press will separate water from the sludge. The water will be returned to the clarifier and the sludge will be disposed as solid waste at an appropriately licensed landfill site;
- **Clean Water Tank:** Will receive disinfected water from the clarifier as well as first pass reverse osmosis (RO) permeates. Water will be supplied from the clean water tank to the following processes:
  - Cooling Towers;
  - Air Separation Unit (ASU) Cooling Towers;
  - Utility Water
  - Potable Water;
  - Gasifier / Reaction Water; and
  - Quench Column and Safety Quench.
- **Cooling Towers and ASU Cooling Towers:** The cooling towers will receive water from the clean water tank and lose some of it to the atmosphere through evaporation and the rest will be sent to the sand filters and GAC with UF units;
- **Utility Water:** Will be supplied from the clean water tanks and used for the different utilities on site;
- **Potable water:** Will be supplied from the clean water tank for domestic and potable use;
- **Gasifier / Reaction Water:** Will be supplied from the clean water tank, as well as water recovered from the super critical water oxidation unit (SCWO) for use underground;
- **Quench Column and Safety Quench:** Will receive water from the clean water tank and send gas liquor to the SCWO;
- **Sand filter and GAC with UF Units:** These units will receive water from the cooling towers and the 2nd pass RO brine from the RO units. They will filter the water and send the UF retentate and sand filter backwash to the clarifier and the rest of the water will go to the RO units;
- **Reverse Osmosis (RO) Units:** Will receive water from the sand filter and GAC with UF Units and send water to the SCWO. The 1st pass RO brine will be sent to the evaporation ponds, the 2nd pass RO brine will be sent back to the sand filter and GAC with UF Units and the 1st pass RO permeate will be sent to the clarifier;
- **Evaporation ponds:** The evaporation ponds will receive the 1st pass RO brine from the RO units; and
- **Super Critical Water Oxidation (SCWO):** Will receive water from the RO units as well as gas liquor from the quench column and the safety quench. Recovered water will go to the gasifier / reaction water units.



Key:
ASU – Air Separation Unit
GAC – Granular Activated Carbon
UF – Ultrafiltration
RO – Reverse Osmosis
SCWO – Super Critical Water Oxidation
Maximum Operating Case – m³/h
Normal Operating Case – m³/h

Figure 11-16: Water Balance schematic for Africary UCG project

11.6.4 Water quality monitoring

The Palmietkuilspruit should be sampled during the rainy season to develop a water quality and flow profile for the river in the vicinity of the site. Sampling for water quality determination should be done as follows:

- One sampling site should be established upstream of the site to measure the baseline water quality in the Palmietkuilspruit before it enters the project area; and
- One sampling site should be established downstream of the site area to measure the water quality exiting the project area.

This will assist Africary and the authorities to identify any source of contamination between the upstream and downstream sampling points. It can also be of considerable value to Africary if the water quality deteriorates over time without any contribution from Africary. Table 11-20 lists the water quality variables that should be monitored at the above monitoring points.

Table 11-20: Water Quality variables to be monitored

Parameter	Frequency
pH	Monthly
Total Dissolved Solids	Monthly
Total Suspended Solids	Monthly
Total Alkalinity	Monthly
Calcium	Monthly
Magnesium	Monthly
Sodium	Monthly
Potassium	Monthly
Chloride	Monthly
Sulphate	Monthly
Fluoride	Monthly
Nitrate	Monthly
Nitrite	Monthly
DOC	Monthly
ICP Scan	Monthly
ICP-OES	Monthly
Oil and grease	Monthly

11.6.5 Impact Assessment

11.6.5.1 Construction

The construction activities described in section 10.1.1 could lead to runoff with a high silt load and contaminants such as fuel, hydraulic fluids, degreasing and other chemicals and cement. The potential impact is rated as being of ***moderate (SP = 55)*** significance. The impact can be reduced to ***low (SP = 10)*** significance by applying the following mitigation measures:

- Construct clean water diversion berms and channels first, before undertaking any other activities;
- Proper construction of the bunded areas and brine ponds is crucial. The bund walls and the walls of the brine ponds must be raised at least one metre above the surrounding ground level to prevent flooding by runoff during heavy rainfall events. Construction must take place under the supervision of an appropriately qualified professional engineer for quality control purposes, with special reference to the integrity of the pond liners and the bunds;
- Undertake construction during the dry season (May to September) if practicable;

- Place drip trays under vehicles when parked;
- Service vehicles in a workshop, not in the field;
- If in-field refuelling is done from a tanker, it should be done in a designated dirty area and a spill kit and clean-up team must be available on site; and
- Spillages should be cleaned up immediately and contaminated soil must either be remediated *in situ* or disposed of at an appropriately licensed landfill site.

11.6.5.2 Operation

The operational phase has the potential to cause contamination of the downstream surface water resources *via* leakage of the bunds and/or brine ponds, overflow of the bunds and/or brine ponds, storage of process chemicals and/or wastes outside of the bunded areas. Contamination of the shallow aquifer by leakage of gas from the underground gasifier past the borehole casings and grouting seals could also migrate into the surface water resources.

Such impacts, although potentially serious, would be temporary and reversible because they could be detected and stopped with relative ease. Accordingly, the potential impact is rated as being of ***moderate (SP = 52)*** significance. The following mitigation measures are recommended to reduce the impact to one of ***low (SP = 14)*** significance:

- Monthly monitoring of the water in the Palmietkuilspruit as stipulated in section 11.6.4;
- Monthly inspection of the clean water diversion channels, clearing them of obstacles to free flow and maintaining them in a good state of repair;
- Implementation of all the mitigation measures against groundwater impacts described in section 11.7.2 below.

11.6.5.3 Closure and rehabilitation

Decommissioning activities are similar to those undertaken during the construction phase and could also lead to runoff with a high silt load and contaminants such as fuel, hydraulic fluids, degreasers and other chemicals.

The potential impact on surface water resources is assessed as being of ***moderate (SP = 55)*** significance. The following measures are recommended to reduce the impact to one of ***low (SP = 10)*** significance:

- The clean water diversion berms, bunds and brine ponds must be the last structures to be demolished;
- Place drip trays under vehicles when parked;
- Service vehicles in a workshop, not in the field;
- If in-field refuelling is done from a tanker, it should be done in a designate dirty area and a spill kit and clean-up team must be available on site;
- Spillages should be cleaned up immediately and contaminated soil must either be remediated *in situ* or disposed of at an appropriately licensed landfill site;
- Rip compacted areas, analyse soil and fertilise appropriately;
- Shape rehabilitation areas to be free draining; and
- Re-vegetate disturbed areas with locally indigenous grasses, shrubs and trees.

11.7 Groundwater

Africary undertook core drilling of 9 new exploration boreholes (TUCG01 to TUCG09 – see Figure 11-17) during November – December 2013 to characterise the coal reserves in the preferred target area more accurately. Packer and pump tests were done on boreholes TUCG02 and TUCG09, which are respectively up-gradient and down-gradient of the UCG target area, to determine the hydrogeological characteristics of

the various strata and to develop the conceptual hydrogeological model shown in Figure 11-18. The hydraulic conductivity values determined for each tested interval are presented in Table 11-21 (Muresan, M;, February 2014).

Table 11-21: Summary of packer test results

Borehole TUCG02			Borehole TUCG09		
From, mbgl	To, mbgl	K, m/d	From, mbgl	To, mbgl	K, m/d
108	111	4.36×10^{-04}	125	128	3.67×10^{-03}
173	176	8.42×10^{-03}	154	157	3.06×10^{-04}
210	213	6.71×10^{-03}	247	250	3.83×10^{-04}
230	233	7.41×10^{-03}	240	343	9.60×10^{-04}
303	304	3.19×10^{-02}	350	352	8.72×10^{-03}
321	324	9.17×10^{-03}	369	372	1.20×10^{-02}
330	333	4.19×10^{-03}	375	378	7.71×10^{-03}
334	337	4.49×10^{-03}	378	381	1.82×10^{-03}
338	341	2.17×10^{-03}	382	385	5.47×10^{-03}
341	369	4.03×10^{-04}	385	407	4.50×10^{-04}

K is the hydraulic conductivity of the geological formations and is measured in metres per day.

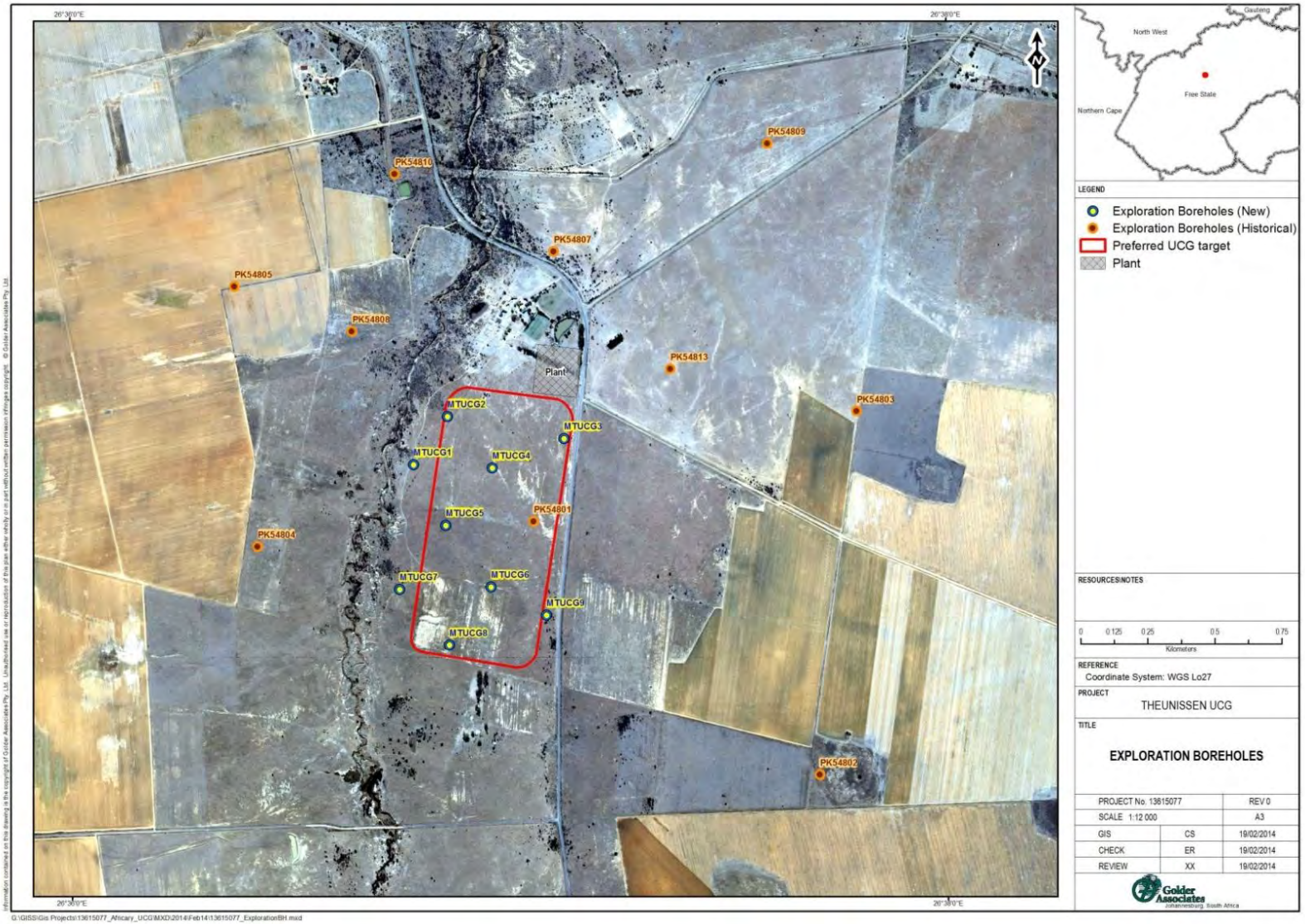


Figure 11-17: Positions of exploration boreholes

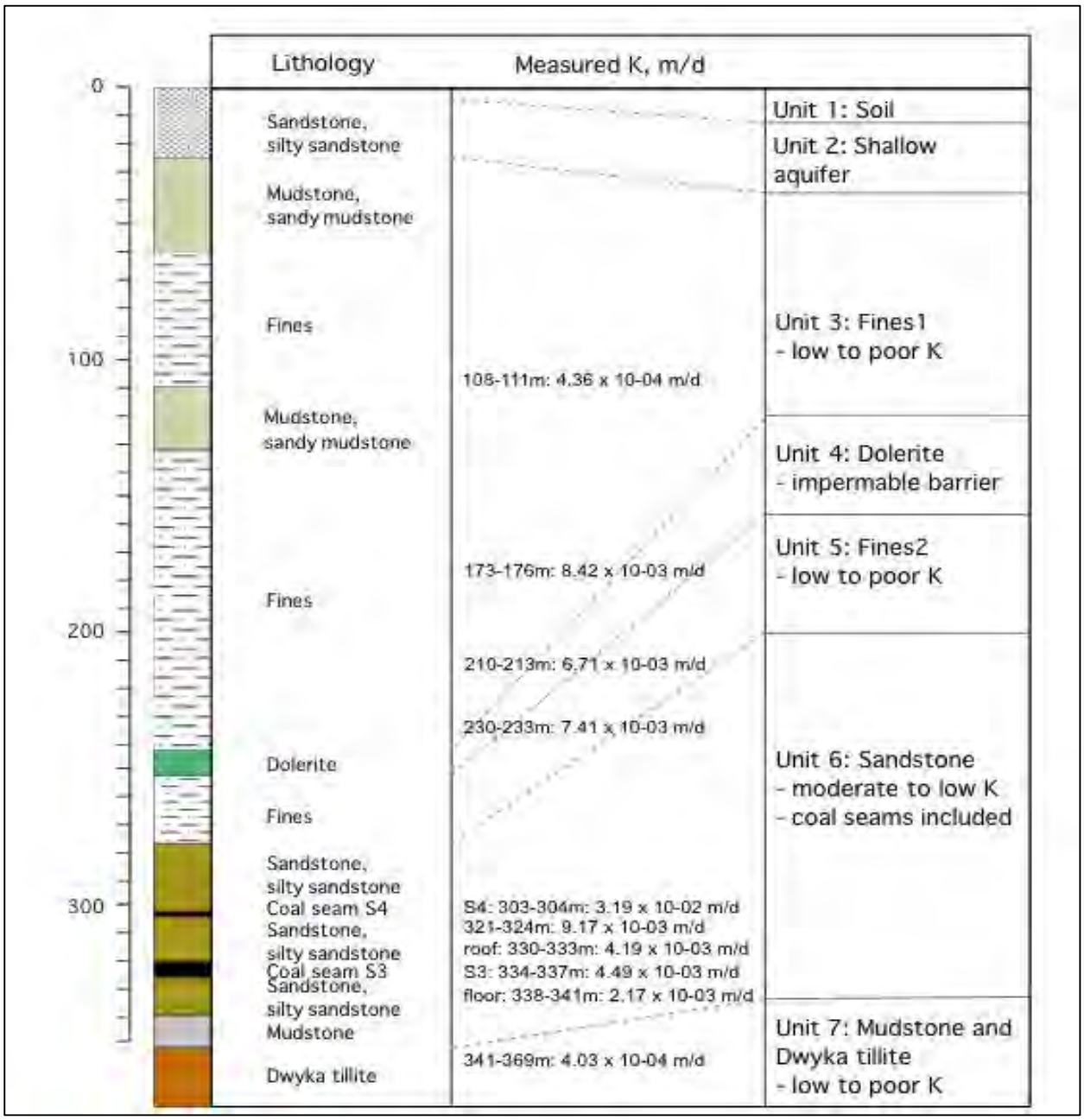


Figure 11-18: Conceptual Hydrogeological Model

The hydrogeological formations incorporated in the model domain were characterized as follows:

- Unit 1: The superficial top unit, with high hydraulic conductivity K, favourable for rainfall recharge.
- Unit 2: The upper aquifer, from which water is abstracted *via* the boreholes shown on Figure 7-21 for agricultural and domestic use in the area.
- Unit 3: Incorporates clayey, laminated, micaceous, carbonaceous, dark, graded contact, bioturbated and with worm burrows, fine sediments and silty, micaceous, carbonaceous, dark grey mudstones. Characterized by low to poor hydraulic conductivity.
- Unit 4: Dolerite; practically impermeable; the packer-test performed in the formation above the dolerite contact (230-233m) where permeability is generally expected indicated very low hydraulic conductivity.
- Unit 5: Similar to Unit 3 and represented by clayey, laminated, micaceous, carbonaceous, dark, graded contact, bioturbated and with worm burrows, fine sediments and silty, micaceous, carbonaceous, dark grey mudstones. Characterized by low to poor hydraulic conductivity.

- Unit 6: This unit is represented by sandstone and silty sandstone and also incorporates the two coal seams; the hydraulic conductivities are moderate to low. The roof and floor formations above and below the S3 coal seam have approximately the same hydraulic conductivity as the coal.
- Unit 7: The packer tests indicated low hydraulic conductivity below the coal seams.

The calculated hydraulic conductivity values indicate relatively low permeability in the formations above and below the target S3 coal seam. The upper and thinner coal seam S4 has slightly higher permeability than the main coal seam S3.

The only permeable horizon suitable for groundwater extraction is represented by the superficial layer hosting the shallow aquifer (<50m from surface). Due to the low permeability values encountered no pumping tests were done in the lower units.

11.7.1 Construction

The construction activities described in section 10.1.1 could lead to contamination of soil and subsequently groundwater in the shallow aquifer through spillages of fuels, lubricants, hydraulic fluids and chemicals such as solvents, degreasers and cement. Groundwater may also be impacted by poor sanitation practices of construction workers.

The potential impact is assessed as being of ***moderate (SP = 60)*** significance. The following measures are recommended to reduce it to one of ***low (SP = 24)*** significance:

- Monthly monitoring with regard to water levels and water quality of shallow aquifer boreholes BH2 and BH3 up-gradient and BH1 down-gradient of the proposed construction area;
- Place drip trays under vehicles when parked;
- Service vehicles in a workshop, not in the field;
- If in-field refuelling is done from a tanker, it should be done in a designated dirty area and a spill kit and clean-up team must be available on site;
- Spillages should be cleaned up immediately and contaminated soil should either be remediated *in situ* or disposed of at an appropriately licensed landfill site;
- Provide adequate sanitation facilities in the form of chemical toilets that are serviced regularly; and
- Provide environmental awareness training for workers on site.

11.7.2 Operation

The hydraulic conductivity values were used in the development of a numerical groundwater model with sufficient geometric refinement to be used in detailed simulations without a need for model re-construction for the operational phase. The model was constructed using *Feflow* (DHI-Wasy) finite element code.

A steady state calibration process was undertaken with the initial parameters assigned to the model until an adequate correlation was achieved between the observed water levels at the hydrocensus observation points and the computed water levels. See Figure 11-19.

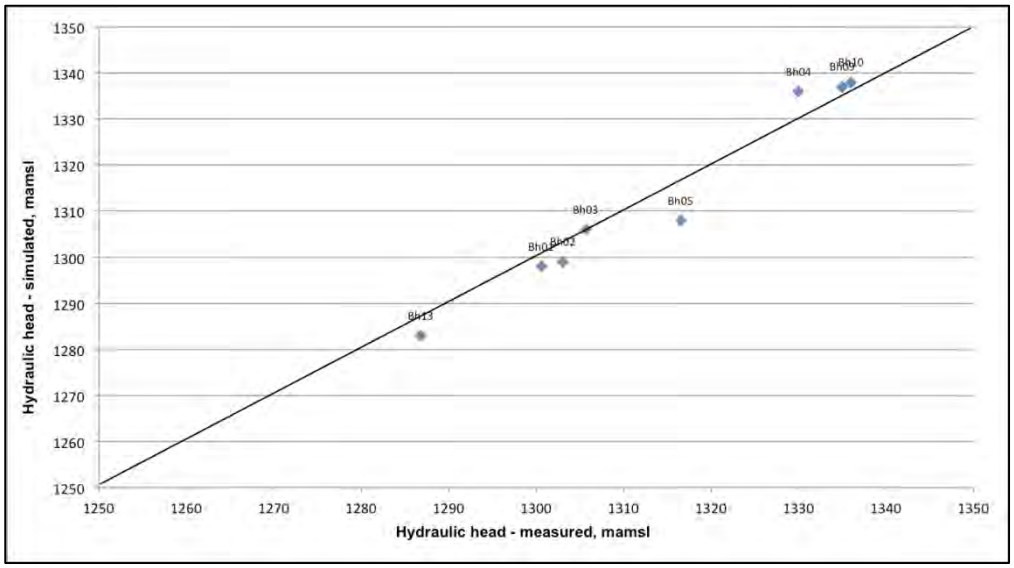


Figure 11-19: Steady state calibration - computed vs. measured water levels

The calibration achieved is considered to be good in terms of the guidelines of the American Society for Testing and Materials (ASTM) as recommended for the evaluation of groundwater models.The calibrated hydraulic conductivity values which were used in the predictive simulations are shown in Table 11-22.

The calibrated rainfall recharge is 0.2 mm/day. This equals recharge of 1% of MAP, which is to be expected in the project area.

Table 11-22: Calibrated hydraulic conductivity values

Layer	Name	Thickness, m	K_{mod}, m/d	K_h, m/d	K_v, m/d
1	Soil	5	5.00 x 10-01	5.00 x 10-01	5.00 x 10-01
2	Weathered	<40m	8.00 x 10-01	8.00 x 10-01	8.00 x 10-02
3	Fines1	Variable	3.50 x 10-03	3.50 x 10-04	5.00 x 10-04
4	DOL	10	1.00 x 10-05	1.00 x 10-05	1.00 x 10-05
5	Fines2	Variable	2.00 x 10-03	2.00 x 10-03	2.00 x 10-04
6	S4	2	1.20 x 10-02	1.20 x 10-02	1.20 x 10-03
7	Fines3	Variable	1.00 x 10-02	1.00 x 10-02	1.00 x 10-03
8	Goaf3	5	1.00 x 10-03	1.00 x 10-03	1.00 x 10-03
9	Goaf2	7	2.00 x 10-02	2.00 x 10-02	2.00 x 10-02
10	Goaf1	7	5.90 x 10-03	5.90 x 10-03	5.90 x 10-03
11	S3	3	3.15 x 10-03	3.15 x 10-03	3.15 x 10-03
12	Floor1	5	3.80 x 10-03	3.80 x 10-03	3.80 x 10-04
13	Floor2	5	5.00 x 10-04	5.00 x 10-04	5.00 x 10-05
14	Fines4	variable	1.00 x 10-03	1.00 x 10-03	1.00 x 10-04
15	BMT	variable	4.00 x 10-04	4.00 x 10-04	4.00 x 10-04

Note:

K_{mod} = generic hydraulic conductivity assigned to the formations. Measurements were used where available; where not available, theoretical values based on Golder's knowledge of the formations was used;

K_h = horizontal K;

K_v = vertical K used initially in the pre-calibration of the model.

The combustion front will propagate along the coal seam during the UCG process, creating a progressive cavity. Deformation of the layers above the gasifier cavity, a process known as "goafing" will occur at a rate determined by the thermic and geomechanical properties of the coal and surrounding strata. The rate and

extent of deformation are site-specific and can only be determined after the gasification process has taken place.

The following changes in hydraulic properties during UCG were assumed for the Theunissen UCG groundwater model using Paul Younger's diagram.

Table 11-23: Changes of hydraulic properties for layers affected during UCG

Layer	Name	Thickness, m	Initial K_h, m/d	Initial K_v, m/d	UCG K_h, m/d	UCG K_v, m/d
8	Goaf3	5	1.00×10^{-03}	1.00×10^{-03}	5.0×10^{-03}	5.0×10^{-03}
9	Goaf2	7	2.00×10^{-02}	2.00×10^{-02}	1.0×10^{-01}	1.0×10^{-01}
10	Goaf1	7	5.90×10^{-03}	5.90×10^{-03}	6.0×10^{-01}	6.0×10^{-01}
11	Seam S3	3	3.15×10^{-03}	3.15×10^{-03}	6.0×10^{-01}	6.0×10^{-01}

The UCG process will be operated at a lower pressure than the hydrostatic pressure of the groundwater at the depth of the coal seam. Groundwater will flow into the gasifier and react with the coal to form syngas. Due to the very low hydraulic conductivity of the rock strata surrounding the coal seam, additional water will be supplied *via* the injection well to sustain the desired syngas production rate.

Gasification of the preferred target area (Figure 5-1) will take place over a length of 950 metres and a width of 480 metres. It is expected that the combustion front will advance at a rate of 0.5m/day, i.e. the coal in the target area will be consumed in about 5 years, after which new injection and production wells may be drilled into a different part of the coal seam. If the initial 5-year gasification project is technically and commercially successful the process may be extended to the entire coal field over which Africary has rights Figure 2-2 and the production rate may be increased by operating several gasifiers simultaneously.

The numerical model was used to investigate the groundwater behaviour at 120 time intervals of 30.43 days each for a period of 10 years, i.e. 5 years of gasification plus 5 years afterwards. The main findings are:

- Due to the thickness of the layers above the coal seam and their low hydraulic conductivity, the shallow aquifer is isolated from the coal seam and the UCG process should not have any effect on the shallow aquifer from which groundwater is abstracted for agricultural and domestic use. The dolerite dyke above the gasifier (layer 4) constitutes a very good geological cap.
- A zone of decreased hydraulic pressure will develop around the gasifier. The pressure gradients will undergo almost complete recovery after a period equal to the gasification period.
- Due to the development of a zone of decreased pressure around the gasifier, groundwater will flow towards the gasifier and there is no risk of contamination by mobilisation and transport of contaminants from the gasifier into the groundwater.
- Due to the low hydraulic conductivity of the geological formations surrounding the coal seam, the pre-UCG hydraulic head further away from the gasifier will remain unaffected and it will take several hundred years for the gasifier to be filled by the inward flow of groundwater.
- After the gasifier has filled up with water, there will be very little to no flow of groundwater through the gasifier and no risk of significant contamination of groundwater further afield.

Cross-contamination between shallow and deep aquifers that are separated by geological formations with low permeability can occur due to inappropriate borehole construction.

Exploration boreholes can fill by migration of water from the shallow aquifer into the boreholes, but there would not be significant mobility beyond the boreholes. All exploration boreholes into the coal seam must be properly sealed before gasification commences to prevent the escape of the syngas *via* these boreholes into the atmosphere and potential contamination of the shallow aquifer.

Proper casing and grouting of the injection and production boreholes to an adequate depth is essential to prevent the escape of syngas *via* any gaps between the casing and the borehole wall.

Similar to the construction phase, the operational phase activities could also lead to contamination of soil and subsequently groundwater in the shallow aquifer through spillages of fuels, lubricants, hydraulic fluids and chemicals such as solvents, degreasers and cement. The same mitigation measures should be applied.

Taking the possibility of inadequate borehole construction into account, the potential impact on the shallow aquifer is rated as being of ***high (SP = 75)*** significance. The following mitigation measures are recommended to reduce it to one of ***low (SP = 7)*** significance:

- All exploration boreholes into the coal seam should be hermetically sealed with concrete or grouting mix;
- Drilling of the injection and production boreholes should be undertaken by a specialist drilling contractor with adequate experience of gas or oil drilling and a proper understanding of the required casing and grouting specifications;
- The pressure in the gasifier should be monitored continuously and the rate of gasification should at all times be controlled to maintain the pressure in the gasifier at a lower level than the hydraulic pressure in the surrounding geological formations;
- At the end of the life of a gasifier, the disused injection and production boreholes should also be hermetically sealed with concrete or grouting mix;
- Additional groundwater modelling during the operational phase should simulate water injection into the goaf zones, targeting specific intervals, to maintain a higher hydraulic head in the goaf zones. Numerical modelling will determine the volume of water to be injected in such zones and the efficiency thereof. The results will determine the extent to which this practice is to be recommended; and
- Monthly monitoring with regard to water levels and water quality of shallow aquifer boreholes up-gradient and down-gradient of the power plant site.

11.7.3 Closure and rehabilitation

The closure and rehabilitation activities described in section 10.1.3 could lead to contamination of soil and subsequently groundwater in the shallow aquifer through spillages of fuels, lubricants, hydraulic fluids, brine and chemicals such as solvents, degreasers and cement.

The potential impact is assessed as being of ***moderate (SP = 60)*** significance. The following measures are recommended to reduce it to one of ***low (SP = 24)*** significance:

- Place drip trays under vehicles when parked;
- Service vehicles in a workshop, not in the field;
- If in-field refuelling is done from a tanker, it should be done in a designated dirty area and a spill kit and clean-up team must be available on site;
- Spillages should be cleaned up immediately and contaminated soil should either be remediated *in situ* or disposed of at an appropriately licensed landfill site;
- Provide environmental awareness training for workers on site; and
- Monthly monitoring with regard to water levels and water quality of shallow aquifer boreholes up-gradient and down-gradient of the power plant site until demolition activities have been completed and three-monthly for three years afterwards.

11.8 Terrestrial Ecology

11.8.1 Construction

The construction activities described in section 10.1.1 will result in the total removal of vegetation and topsoil from an area of about 3 ha on the power plant site and from a 2 metre wide strip along the pipeline route. The latter disturbance will not occur if Africary enters into a water supply agreement with the Sand-Vet Water Users Association, but if the pipeline is constructed, the trench will be backfilled and the surface will be revegetated immediately after construction. Earth moving and transport activities will generate dust that will settle on vegetation in the area, reducing its ability to photosynthesise and its palatability to herbivores.

Human presence and construction noise are likely to drive most species of fauna away.

Taking into account the ecological characteristics and the extent of the areas affected, the impact is assessed as being of ***moderate (SP = 65)*** significance. The impact can be reduced to one of ***moderate (SP = 45)*** significance by implementing the following mitigation measures:

- Clear demarcation of all construction and laydown areas, which should be chosen to minimise the disturbance footprint and the number of trees that must unavoidably be removed;
- Designation of no-go areas, e.g. the riparian areas of the Palmietkuilspruit and the area on the alternative site where the small geophytes grow;
- All construction personnel should receive training in environmental awareness and the recognition of Red Data species. If any Red Data species such as the Harlequin Snake or Aardvark are found, the services of a suitable specialist should be sourced to advise on their safety and whether relocation is required;
- Strong sanctions against the hunting, trapping, killing or otherwise harming of all species;
- Relocation of all geophytes within the affected footprint to suitable habitat by a properly qualified person prior to the commencement of construction activities;
- Restriction of vehicle movement to existing roads and farm tracks;
- Dust control by wet suppression;
- All disturbed areas should be re-vegetated with locally indigenous species; and
- Monitoring and auditing of the construction activities for compliance with the project-specific Environmental Management Programme (EMP). After installation of the pipeline and power line, the route should be inspected quarterly until the construction disturbances have been appropriately rehabilitated.

11.8.2 Operation

The operational activities described in section 10.1.2 are unlikely to have any significant adverse effects on the vegetation on and in the vicinity of the power plant site and the power plant route. Minor vegetation disturbances will occur whenever new injection and production wells are drilled during the operational life of the project.

The constant human presence at the power plant site and the noise generated on the site are likely to keep many species of fauna away for the duration of the operational phase, thereby reducing the biodiversity in the vicinity of the site. Hunting, trapping, killing or otherwise harming of fauna and unnecessary disturbance of vegetation would exacerbate the impact.

Without mitigation, the impact is assessed as being of ***moderate (SP = 48)*** significance. The impact can be reduced to one of ***low (SP = 16)*** significance by implementing the following mitigation measures:

- Monitoring for and control of declared weeds and invasive flora on the power plant site and along the length of the pipeline and power line route. Plants such as *Opuntia* sp. should be controlled mechanically and disposed of appropriately (compost heap or landfill). The re-occurrence or spread of declared weeds and invasive plants must be controlled by the land user as per the legal requirements of the CARA;
- All personnel should receive training in environmental awareness and the recognition of Red Data species. If any Red Data species are observed, the services of a suitable specialist should be sourced to advise on their safety and whether relocation is required;
- Designation of no-go areas, e.g. the riparian areas of the Palmietkuilspruit and the area on the alternative site where the small geophytes grow;
- Strong sanctions against the hunting, trapping, killing or otherwise harming of all species;
- Restriction of vehicle movement to existing roads and farm tracks; and
- Dust control by wet suppression.

11.8.3 Closure and rehabilitation

If rehabilitation is not undertaken correctly, if soil pollution occurs during closure and if the disturbed soil is colonised by weeds and alien invader species, the ecological quality of the degraded vegetation currently

present on the power plant site could deteriorate even further, leading to an adverse impact of ***moderate (SP = 48)*** significance, but only because the area involved is relatively small.

Implementation of the following measures could improve the ecology on the site from its pre-project condition and result in a positive impact of ***moderate (SP = +39)*** significance:

- Remove steel structures, demolish brick and concrete structures, remove building rubble and dispose of it in accordance with applicable regulatory requirements;
- Remove sediment, brine and liners from brine ponds and dispose in accordance with applicable regulatory requirements, taking particular care to avoid spillage. If spillages do occur, they should be cleaned up immediately and any contaminated soil should be disposed of in accordance with applicable regulatory requirements;
- Remove all weeds and alien plants from the site;
- Rip compacted areas and shape the surface of the site to be free draining. Spread stockpiled subsoil first, then topsoil that has been preserved in the storm water diversion berm and the topsoil stockpile. Take care to avoid mixing of subsoil with topsoil. Use light agricultural machinery to avoid compaction;
- Do soil analysis and add soil conditioners and fertilisers as recommended by a qualified soil scientist;
- Re-vegetate with locally indigenous grasses, shrubs and trees to encourage colonisation by fauna; and
- Monitor quarterly until the vegetation has become self-sustaining. If any bare patches develop, the reason should be investigated and addressed, followed by re-vegetation of the patch.

11.9 Socio-economics

Figures for both the construction and operations phase were supplied by Africary during the pre-feasibility study for the proposed project and their accuracy is estimated at ±30 - 50%.

11.9.1 Construction

The construction phase, which will be undertaken by one or more contractors, will require the services of about 150 to 200 workers for a period of about 12 to 15 months. The skills breakdown of the contract work force will be about 30% unskilled, 30% semi-skilled and 40% skilled.

The capital expenditure is estimated at approximately R1.5 billion comprising of capital goods and services procurement (65%), wages (15%) and VAT (14%). The local content of the capital expenditure is estimated at 20% for labour and 27% for fabrication.

Taking into consideration that the Lejweleputswa District Municipality has a working age population in excess of 200 000 (section 7.10.3) and an unemployment rate approaching 40% (section 7.10.4), the construction workforce will represent less than 0.25% of the number of unemployed people. While this will be a positive socio-economic impact, there is always an expectation that a new project will employ many of the local people and such expectations can lead to negative impacts.

The capital expenditure of R1.5 billion, albeit very significant in its own right, will contribute less than 1% to the regional GDP (section 7.10.2) for the year in which it is spent.

The socio-economic impact of the construction phase is assessed as positive, but of ***low (SP = +12)*** significance. It can be enhanced to one of ***low (SP = +18)*** significance by implementation of the following measures:

- Careful management of expectations of employment and other socio-economic benefits through effective communication with local communities;
- Preferentially appointing, where practicable and economically feasible, local contractors;
- Giving preference, where practicable and economically feasible, to local suppliers of goods and services;
- Creating and maintaining a communication channel (name, phone and fax number, e-mail) that members of the public can use to lodge complaints, pose questions and ask for information; and
- Creating and maintaining a complaints register, following up on every complaint and giving responses until the complaint is closed out.

11.9.2 Operation

The personnel complement for the operational phase of the UCG project is shown in Table 11-24. The skills breakdown will be 33% skilled, 40% semi-skilled and 27% unskilled. There will be 19 people on site during office hours and the day shift, and 7 during the other two shifts.

Table 11-24: Personnel Complement

Management		Operations		Maintenance	
Plant Manager	1	Manager/Process Eng	1	Manager/Mechanical Eng	1
Asst Manager	1	Electrical Eng	1	Foreman	2
Secretary	1	Shift Supervisors	4	Planner/Buyer	1
HSE Coordinator	1	Operators	6	Computer Techs	1
		Chemists (Lab)	1	Mechanics	2
		Clerk	1	Electricians	2
Security	4			Labourers	2
	8		14		11
TOTAL:			33		

The power output of 50 - 60 MW will add about 0.125% to the national power generation capacity.

The main input into the power generation plant will be gas produced in the gasifier. The only other significant input will be raw water. Africary have estimated the annual operating cost to be in the region of R300 million, which is less than 0.2% of the regional GDP (see section 7.10.2). As documented in the specialist studies on cultural and heritage resources, air quality, noise, surface water and groundwater, the impacts on current residents in the vicinity of the power plant site will be low. The nearest industrial installation (Beatrix gold mine) is located about 8 kilometres from the power plant site and is not expected to experience any notable impact.

The socio-economic impact of the operating phase will be positive, but effectively too small to assess in terms of the methodology described in section 9.2 and it is rated as having ***very low (SP = +4)*** significance within the context of the socio-economic parameters of the region, the province and the country.

Not much can be done to enhance the socio-economic impact, apart from applying the mitigation measures as recommended in this EIA to minimise the environmental impacts, but the current Africary project should be viewed as a demonstration project. If it and other UCG projects being undertaken and planned in South Africa and other coal-rich countries around the world prove to be technically, environmentally and commercially successful, the socio-economic benefits in terms of unlocking the energy potential of huge underground coal reserves in a safer, more economical and more environmentally friendly manner than current coal mining practices, could be highly significant.

11.9.3 Closure and rehabilitation

The activities undertaken during this phase will have similar, but smaller positive socio-economic impacts than the construction phase, partly because of their shorter duration and smaller number of contract workers, but also because the small positive contribution of the operating phase (15 jobs and 50-60 MW delivered to the national grid) will fall away.

The impact is therefore assessed as being positive, but of ***low (SP = +12)*** significance. It can be enhanced to one of ***low (SP = +18)*** significance by implementation of the following recommended measures:

- Skills development and training of employees to enhance their value in the labour market and thereby their chances of finding employment after project closure;
- Development of a retrenchment plan in consultation with employees, starting at least five years before closure;

- Assisting redundant employees to find alternative employment as far as practicable;
- Focusing specifically on sustainable community projects in the SLP, i.e. projects that will remain viable without continued support from Africary; and
- Leaving intact such infrastructure as can be used by local communities, after consultation with the communities.

11.10 Cultural and Heritage Resources

11.10.1 Construction

None of the identified historical structures are located closer than 90 metres from the perimeter of the preferred power plant site. Graveyard GY01 is situated about 300 m to the west of the site and graveyard GY02 is situated approximately 20 metres from the shoulder of the dirt road where the electrical power line may run. None of the identified cultural and heritage resources need be affected by the proposed UCG project and the construction phase as described in section 10.1.1 should have ***no (SP = 0)*** impact on the formal graveyard.

However, it is always possible that an unknown grave or other buried cultural/archaeological items could be unearthed when excavations are being undertaken. In such an event the following chance find procedure must be implemented to mitigate the potential impact from one of ***high (SP = 80)*** to one of ***low (SP = 21)*** significance:

- Cease all work in the immediate vicinity of the find;
- Demarcate the area with barrier tape or other highly visible means;
- Notify the South African Heritage Resources Authority (SAHRA) immediately;
- Commission an archaeologist accredited with the Association for Southern African Professional Archaeologists (ASAPA) to assess the find and determine appropriate mitigation measures. These may include obtaining the necessary authorisation from SAHRA to undertake the mitigation measures; and
- Prevent access to the find by unqualified persons until the assessment and mitigation processes have been completed.

11.10.2 Operation

The activities undertaken during the operational phase need not have any impact on the historical structures or the graves, but with heightened human activity at the power plant site and on the preferred UCG target area over a long period of time, the probability of damage to these resources could increase. Conversely, Africary's presence on the property could help to prevent casual vandalism and theft of structural components.

Without mitigation measures, the impact could be of ***moderate (SP = 48)*** significance. The following measures are recommended to reduce it to one of ***low (SP = 16)*** significance:

- Awareness training of personnel;
- Erecting a fence with a lockable gate around GY01. GY02 is not located on land over which Africary can exercise control;
- Strict sanctions against damaging any of the resources;
- Repairing any damage that may occur; and
- Occupying and maintaining historical structures for beneficial use, where practical.

11.10.3 Closure and rehabilitation

The closure and rehabilitation phase as described in section 10.1.3 should have ***no (SP = 0)*** impact on any identified cultural and heritage resources and no mitigation measures are required.

11.11 Visual

11.11.1 Construction

The potential for a daytime visual impact during the construction phase is expected to be associated mainly with the generation of dust due to the vegetation clearing and excavation activities and vehicles travelling over unpaved surfaces. The night-time visual impact will be due to security lighting at the construction site and the headlights of vehicles. The impact is assessed as one of ***moderate (SP = 65)*** significance and it can be further reduced to a ***low (SP = 24)*** significance by dust suppression with water or chemicals, by limiting vehicle movement at night and by installing motion-sensitive lighting that is directed downwards and inwards towards the site.

11.11.2 Operation

The power plant site will contain various geometric components with metallic, concrete and painted surfaces that will contrast sharply with the existing visual properties of the area. Certain elements of the plant will be large and tall, resulting in a high level of visual intrusion. Dust generation from unpaved surfaces would add to the visibility. When operating, the flare will be highly visible, especially at night. Lighting will be visually intrusive at night. Ancillary infrastructure such as roads, fences and power lines will be similar in nature to existing features in the landscape and will result in low to moderate levels of visual intrusion.

Without mitigation, the visual impact of the installations on the power plant site is rated as being of ***high (SP = 85)*** significance. The impact can be mitigated to one of ***moderate (SP = 65)*** significance by implementing the following mitigation measures:

- Avoid bright, shiny, reflective surfaces such as galvanised steel cladding. Paint surfaces in matt pastel colours (brown, olive green, light grey, grey-green, blue grey, dark buff, rust, ochre, variations of tan) that blend in with the background;
- Plant and maintain a screen of indigenous trees around the perimeter of the power plant site;
- Plan the lighting requirements of the facilities to provide lighting that meets operational requirements without resulting in excessive illumination;
- Identify zones of high and low lighting requirements, focusing on only illuminating areas to the minimum extent possible to allow safe operations at night and for security purposes;
- Lighting should be directed inwards, downwards and, where possible, away from the local roads and farmhouses;
- Reduce the height from which floodlights are fixed as much possible while still maintaining the required levels of illumination;
- Avoid up-lighting of structures by directing lighting downwards and focused on the area to be illuminated;
- Avoid flaring at night if possible;
- Use enclosed ground flares instead of candle flares; and
- Pave access road and bare soil on the plant site.

11.11.3 Closure and rehabilitation

Without an effective tree screen around the power plant site this phase will have the same potential for visual impact as the construction phase, but it will be of shorter duration (6 to 9 months). The visual impacts are therefore expected to be of ***moderate (SP = 65)*** significance without mitigation and ***low (SP = 18)*** significance with the following mitigation measures:

- Maintenance of an effective tree screen;
- Dust suppression with water or chemicals;
- Limiting of vehicle movement at night; and
- Motion-sensitive lighting that is directed downwards and inwards towards the site.

12.0 SUMMARY OF ENVIRONMENTAL IMPACTS

12.1 Construction Phase

Table 12-1 below summarises those impacts directly related to the Construction Phase of the proposed project, and provides a significance rating for each impact before and after mitigation.

Table 12-1: Environmental Impact Assessment Matrix for the construction phase of the proposed underground coal gasification project near Theunissen

POTENTIAL ENVIRONMENTAL IMPACT: CONSTRUCTION PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
1. Air Quality												
Site preparation, excavation of dam basin, channels and pipeline trenches, transport of material and repair of erosion rills will cause mobilisation of particulates	6	2	2	5	50	**Mod**	2	2	1	2	10	**Low**
2. Noise												
Impact will be limited by distance, existing noise levels at NSAs and relatively short construction period	4	2	2	4	32	**Mod**	2	2	2	3	18	**Low**
3. Topography												
Construction of the stormwater management system, brine ponds and buildings will have a minor and reversible effect on the topography of the site with a low probability of it being viewed as significant	2	4	1	2	14	**Low**	2	4	1	2	14	**Low**
4. Geology												
Confined to near surface at power plant site and to borehole diameters at injection and production wells	1	4	1	2	12	**Low**	1	4	1	2	12	**Low**
5. Soils, land capability and land use												
Topsoil will be stripped and stockpiled. Erodible soil, high potential for loss. Soil disturbance along power line route	4	4	1	5	45	**Mod**	2	4	1	3	21	**Low**
6. Surface water and drainage												
Mobilisation of soil and accidental spillage of oil or other hydrocarbons and pollutants from construction vehicles may result in surface water contamination.	6	2	3	5	55	**Mod**	2	2	1	2	10	**Low**
7. Groundwater												
Potential contamination of soil and shallow aquifer *via* spillages of fuels, lubricants, hydraulic fluids, solvents, degreasers and cement and poor sanitation practices of construction workers	8	4	3	4	60	**Mod**	4	2	2	3	24	**Low**
8. Ecology: fauna and flora												
Removal of vegetation and topsoil on power plant site and temporary disturbance along power line and pipeline route. Hunting, trapping or killing of fauna.	8	4	1	5	65	**Mod**	4	4	1	5	45	**Mod**

POTENTIAL ENVIRONMENTAL IMPACT: CONSTRUCTION PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
9. Socio-economics												
Creation of employment opportunities and local spend on goods, materials and services	2	2	2	2	+12	Low	2	2	2	3	+18	Low
10. Cultural and Heritage												
There are no archaeological, cultural or heritage resources on the site and hence no impacts are expected	0	0	0	0	0	None	0	0	0	0	0	None
Impacts will occur only if remains or artefacts are unearthed during earthmoving operations	10	5	1	5	80	High	4	2	1	3	21	Low
11. Visual aspects												
Visible dust from earthworks – excavation of dam basins, water channels and pipe trenches. Security lighting at night	8	2	3	5	65	Mod	4	2	2	3	24	Low

12.2 Operational Phase

Table 12-2: Environmental Impact Assessment Matrix for operational phase of the proposed underground coal gasification project near Theunissen

POTENTIAL ENVIRONMENTAL IMPACT: OPERATIONAL PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
1. Air Quality												
Venting and flaring may cause local high concentrations of CO and SO_2, but not exceedances of ambient AQ standards. Normal operation will have little effect	2	4	3	5	45	Mod	2	4	3	4	36	Mod
2. Noise												
The gas turbine will be audible at all NSAs, unacceptable at NSA 1, intrusive at NSA 7 and 8. Use of gas engines will result in lower noise levels and is recommended	10	4	3	5	85	High	4	4	3	5	55	Mod
3. Topography												
The coal gasification is unlikely to result in	2	4	1	1	7	Very low	2	4	1	1	7	Very low

POTENTIAL ENVIRONMENTAL IMPACT: OPERATIONAL PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
significant surface subsidence												
4. Geology												
Operational phase will result in consumption of effectively all the coal in each gasifier	10	5	2	5	85	**High**	10	5	2	5	85	**High**
5. Soils, land and capability and land use												
Potential for soil contamination due to erosion and spillages at power plant site	8	4	1	4	52	**Mod**	2	4	1	2	14	**Low**
6. Surface water and drainage												
Contamination of surface water due to leaks/overflows at bunded areas/brine ponds inappropriate storage of chemicals/wastes or gas contamination of shallow aquifer	8	2	3	4	52	**Mod**	2	2	3	2	14	**Low**
7. Groundwater												
Inadequate borehole construction could lead to contamination of shallow aquifer by fugitive syngas	8	4	3	5	75	**High**	1	4	2	1	7	**Low**
8. Ecology: fauna and flora												
Human presence and noise is likely to keep fauna away from the vicinity of the plant site. Hunting, trapping or killing of fauna and disturbance of vegetation would reduce biodiversity	6	4	2	4	48	**Mod**	2	4	2	2	16	**Low**
9. Socio-economics												
Operation will require only 15 personnel and add	0	4	0	1	+4	**Very Low**	0	4	0	1	+4	**Very Low**

POTENTIAL ENVIRONMENTAL IMPACT: OPERATIONAL PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
50-60MW to the national grid.												
10. Cultural and Heritage												
Increased human activity at the power plant site and UCG target area could result in damage to the historical structures and graves	10	5	1	3	48	Mod	2	5	1	2	16	Low
11. Visual aspects												
Large and tall structures on the site, night lighting and flaring will be highly visible and intrusive	10	4	3	5	85	High	6	4	3	5	65	Mod

12.3 Closure and rehabilitation Phase

Table 12-3: Environmental Impact Assessment Matrix for the decommissioning and rehabilitation phase of the proposed underground coal gasification project near Theunissen

POTENTIAL ENVIRONMENTAL IMPACT: CLOSURE AND REHABILITATION PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
1. Air Quality												
Considerations and impacts similar to construction phase	6	2	2	5	50	Mod	2	2	1	2	10	Low
2. Noise												
Noise levels at NSAs due to noise generated by vehicles and machines	4	2	2	4	32	Mod	2	2	2	2	12	Low
3. Topography												
Site topography will be restored to its original state. Goafing will continue for some time, but significant surface subsidence is unlikely	1	5	1	1	7	Very low	1	5	1	1	7	Very low
4. Geology												
No effect on geology	0	5	2	0	0	None	0	5	2	0	0	None
5. Soils, land use and land capability												
Mixing of topsoil with subsoil during rehabilitation of the PC dam and brine pond basins would have an adverse impact on these relatively small areas	6	5	1	5	60	Mod	2	5	1	2	16	Low
	0	4	1	0	0	None	4	5	1	4	+40	Mod
6. Surface water and drainage												
Mobilisation of soil and accidental spillage of oil or other hydrocarbons and pollutants	6	2	3	5	55	Mod	2	2	1	2	10	Low

POTENTIAL ENVIRONMENTAL IMPACT: CLOSURE AND REHABILITATION PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
from construction vehicles may result in surface water contamination.												
7 Groundwater												
Potential contamination of soil and shallow aquifer *via* spillages of fuels, lubricants, hydraulic fluids, brine, solvents, degreasers and cement	8	4	3	4	60	**Mod**	4	2	2	3	24	**Low**
8. Ecology												
Incorrect rehabilitation could lead to further ecological degradation on the power plant site. Correct rehabilitation could improve on current baseline conditions	6	4	2	4	48	**Mod**	6	5	2	3	+39	**Mod**
9. Socio-economics												
Creation of employment for contractors and local spend on goods, materials and services	1	2	2	2	+10	**Low**	1	2	2	3	+15	**Low**
10. Cultural and Heritage												
The closure and rehabilitation activities cannot affect any sites of archaeological or cultural significance	0	0	1	0	0	**None**	0	0	1	0	0	**None**
11. Visual aspects												
Visible dust from removal of linings from and backfilling of dam basin and water conveyance channels, ripping and profiling compacted areas, vehicle movement, night lighting	8	2	3	5	65	**Mod**	2	2	2	3	18	**Low**

13.0 ENVIRONMENTAL IMPACT STATEMENT

13.1 Summary of key findings of the EIA

The key findings of the EIA are listed here. For a complete description, see section 11.0 of this report.

13.1.1 Air quality

As stated in section 11.1.6.2, no exceedances of the South African National Air Quality Standards (NAAQS) are expected at any off-site receptor points. Venting and flaring, which are expected to be rare occasions, may cause elevated concentrations of CO and SO_2 locally for short periods of time, but not exceedances of the NAAQS.

13.1.2 Noise

As indicated in section 11.2.2, unless expensive additional mitigation measures are implemented, the noise level generated by a gas turbine based power plant would be audible at all eight identified receptors and the night-time level would be unacceptable at the closest receptor. With standard mitigation measures, the noise generated by a gas engine based plant would be significantly lower, being intrusive only at the closest receptor at night, and could be further mitigated at reasonable cost.

13.1.3 Surface water

While contamination due to spillages from the brine pond and/or pollution control dam could cause significant contamination of the Palmietkuilspruit, proper implementation and management of the recommended mitigation measures would render it unlikely. It would also be of relatively short duration. See section 11.6.5

13.1.4 Groundwater

As discussed in section 11.7, leakage of the brine pond and/or pollution control liners, or leakage of producer gas past the grouting seal between a borehole casing and a borehole wall could contaminate the shallow groundwater, but proper construction of the liners and the boreholes would make this unlikely, and any such effect would be of relatively short duration. After the exhaustion of a combustion chamber, groundwater would seep in and leach contaminants from the ash in the chamber, but it would be slow process due to the low hydraulic conductivity of the host rock. The contaminants would take decades to dissipate, but would be confined to the deep aquifer, which is too deep for use as a groundwater resource.

13.1.5 Visual

As noted in sections 9.3 and 11.11 the structures on the infrastructure site will stand out in the rural landscape, which is characterised by a flat terrain with very little screening vegetation.

13.1.6 Waste management

The brine pond and pollution control dam must be appropriately lined, maintained and managed to protect against potential contamination of the soil, surface water and groundwater with Na, K, Ca, Mg, SO_4 and Cl. At closure, the salts, sediments and liners must be disposed of at a suitable hazardous ste.

Other wastes will be stored in skips until they can be removed for recycling or disposal.

13.2 Final site maps

See Figure 2-7, Figure 5-1 and Figure 5-5.

13.3 Summary of positive and negative implications and risks of proposed activity and alternatives

From the discussions in sections 1.0, 2.5.2, 4.0 and 11.9 of this EIA/EMPr Report, the positive aspects of the project can be summarised as follows:

- Beneficial use of deep coal reserves that cannot be viably mined by opencast or underground mining methods;
- Far smaller environmental impacts at surface, as there will be no product coal stockpiles, no discard coal dumps, no waste rock dumps and no ash dumps;
- None of the health and safety risks associated with opencast or underground mining;
- No transport of mined coal by truck, rail conveyor or pipeline required;
- Activities at surface are limited to gas cleaning, power generation and distribution, and waste management – opencast areas, no shaft sinking;
- The project will contribute towards satisfying the country's need for independent power producers to augment the Eskom power supply; and
- The project will create some jobs and inject some cash into the local economy in the form of operating costs, albeit less than conventional coal mining methods would.

The negative implications and risks, as discussed in sections 9.3 11.0, 12.0 and 13.1 of this report, can be summarised as follows:

- **Atmospheric pollution**: If the flaring system fails at a time when flaring cannot be avoided, unburnt producer gas containing CO, CH_4, phenols and other organic compounds will be emitted to the atmosphere. If the gas cleaning system fails or does not work effectively, particulates and sulphur compounds will be emitted to the atmosphere, These are very rare occurrences that would be of short duration, i.e. the risk to any receptor is low;
- **Groundwater pollution**: Inadequate casing and grouting of the injection and production boreholes could result in producer gas leaking into the shallow aquifer. Leakage through the brine pond and/or pollution control dam liners could occur and contaminate the shallow aquifer. Proper construction, followed by monitoring an maintenance would reduce the risk to a low level.

Metals and combustion products could be leached from the ash in the spent combustion chamber and contaminate the deep aquifer, but it would be a very slow process due to the low hydraulic conductivity of the host rock. The effect would dissipate over decades. The aquifer is too deep to be considered as viable source of water, i.e. there is no risk to groundwater users;

- **Surface water**: Spillage from the brine pond and/or pollution control dam could enter the Palmietkuilspruit and flow into the Sand River, but the contamination would dissipate quite quickly. Proper implementation of the recommended mitigation measures woud render such an event unlikely, i.e. the risk is low;
- **Ecology**: The project will remove indigenous and alien vegetation from an area of about 3 ha at the infrastructure site and temporarily disturb vegetation over an area of about 30 ha along the power line route, resulting in a moderate impact that would be largely reversible after closure*;*
- **Noise:** Africary intends using gas engines instead of turbines. This will reduce the risk of unacceptable noise levels being experienced by any receptors. Monitoring and proper maintenance of noise abatement equipment will be necessary to maintain their effectiveness;
- **Visual:** The structures on the infrastructure site will stand out in the rural landscape. Due to the flat terrain and lack of adequate screening vegetation, a moderate and completely reversible visual impact is expected;
- **Soil, land use and land capability:** There will be a risk of erosion and contamination with hydrocarbons, but with proper implementation of mitigation measures, the potential impact wil be low and reversible;
- **Cultural and heritage:** There are two graveyards close to, but not within the footprint of the project infrastructure. They need not be disturbed and the potential for impact resulting from the project is expected to be low.

14.0 IMPACT MANAGEMENT OBJECTIVES AND OUTCOMES FOR INCLUSION IN THE EMPR.

The impact management objectives and outcomes for the proposed Africary UCG project are as follows:

- To maximise the positive and minimise the negative environmental and socio-economic impacts;
- To capture, contain, treat and recycle all contaminated water arising from the operations on site and to prevent the discharge of contaminated water to the environment;
- To construct and operate stormwater management systems in accordance with the requirements of Regulation 704 under the National Water Act.
- To prevent the ingress of contaminants from the brine pond and pollution control dam into the soil and groundwater by appropriate engineering design, construction and management in terms of GN R.633 to R.636;
- To prevent contamination of the shallow groundwater by producer gas leaking past the borehole grouting by monitoring and maintenance as and when required;
- To avoid exceeding the guidelines and standards for ambient air quality, dustfall and emissions as summarised in sections 11.1.1 to 11.1.3 of this report. Wet suppression will be applied during construction. Air quality will be monitored and the mitigation measures described in 11.1.6 must be implemented;
- To keep off-site noise levels at identified receptors within the national standards and guidelines and avoid the exposure of any receptors to intrusive noise levels by applying the monitoring and mitigation measures described in section 11.2;
- To rehabilitate the disturbed areas to a condition fit for grazing and the resumption of ecological function;
- To soften the visual impact of the project by applying the mitigation measures recommended in section 11.11 of this report;
- To avoid damage to the cultural and heritage resources described in section 7.11.3 of this report by appropriate fencing and education of personnel and contractors; and

- To maintain cordial relationships with local residents, authorities and other stakeholders *via* sustained open communication.

14.1 Final proposed alternative

The final preferred site location and layout as shown on Figure Figure 2-7 and Figure 5-1 and the final preferred powerline route as shown on Figure 5-5 were chosen to minimise the impacts on sensitive receptors and the biological environment. As described in section 5.0, a site and layout selection process considering all relevant factors was undertaken.

14.2 Aspects for inclusion as conditions of authorisation

The conditions of authorisation should include:

- Adherence to the EMPr in Part B of this document, sections 15.0 to 17.0;
- Annual internal auditing of environmental performance; and
- Bi-ennial external auditing of environmental performance and providing the DMR with a copy of the audit report.

14.3 Assumptions, uncertainties and gaps in knowledge

The EIA was limited to the scope of the assessment described in detail in sections 7.0 and 11.0 of this document.

Information on the mineral resources, reserves, projected capital and operating costs, project life and production rates was sourced from Africary's Mining Work Programme (MWP), which was prepared by Africary (Brand , J F;, 2015) in terms of the MPRDA.

Some information sourced from the Social and Labour Plan compiled for Africary (Africary Social and Labour Plan, November 2015) was used to inform the socio-economic impact study.

Although all efforts were made by the EIA project team to identify all environmental, social and health aspects, impacts and mitigation measures, errors and omissions may have occurred. The Environmental and Social Management System (ESMS) that was developed as part of the EIA process encompasses a live database that can be adapted and updated should additional information, aspects or impacts be identified. The objective of the ESMS will be for the Africary project team to continually improve environmental and social performance. In addition, according to South African legislation, the EMPr will need to be updated or amended with new information whenever significant changes are made during the life of the Project.

Every effort has been made to engage stakeholders to the extent possible, however not every stakeholder may have been consulted or their comments may not have been recorded accurately. A grievance mechanism will be established through which stakeholders are able to raise grievances and continue to contribute their concerns and issues to the Africary Project team.

14.4 Opinion on whether the activity should be authorised

The environmental assessment practitioner is of the opinion that this project should be authorised.

14.5 Reasons why the project should be authorised

- UCG represents the only viable method of utilising the coal reserves in this and other coalfields with similar characteristics (deep, thin layers of coal that are overlain by competent, impermeable rock and that cannot be mined economically by conventional opencast or underground methods);
- Successful commercial development of UCG through this and other similar projects would pave the way for the utilisation of huge reserves of coal in South Africa and other countries – coal that cannot be accessed by conventional methods;
- UCG has much lower environmental impacts than conventional coal mining – the surface disturbance is negligible (only boreholes) and copmpletely reversible and there are no mining residues (ash, waste rock, discard coal, fines) on the surface. The safety risks associated with conventional mining are also absent;

- Provided that all the environmental management measures described in the EMPr are applied diligently, the proposed underground gasification of coal and the generation and distribution of power within the areas shown on will not have any environmental impacts that cannot be adequately mitigated to protect the environment and local human receptors.and authorisation of Africary's application would be justified on the basis that the positive effects of the project are likely to outweigh the remaining negative impacts;
- Additional generating capacity is vital to South Africa's economic growth; and
- Not granting this authorisation will not necessarily result in the coal reserves remaining permanently unexploited. As long as there is a demand for electricity, coupled with economically viable technologies to utilise the coal, there will be a drive to do so.

14.6 Conditions that must be included in the authorisation

14.6.1 General conditions

Africary must:

- Implement all aspects of the EMPr in sections Part B of this document (sections 15.0 to 17.0;
- Comply with all relevant legislation at all times;
- Undertake bi-annual internal auditing of environmental performance and annual reporting to the DMR; and
- Undertake bi-ennial external auditing of environmental performance and provide the DMR with a copy of the audit report.

14.6.2 Specific conditions

Africary must:

- Capture, contain, treat and recycle all contaminated water arising from the operations on site and prevent the discharge of contaminated water to the environment;
- Construct and operate stormwater management systems in accordance with the requirements of Regulation 704 under the National Water Act;
- Prevent the ingress of contaminants from the brine pond and pollution control dam into the soil and groundwater by appropriate engineering design, construction and management in terms of GN R.633 to R.636;
- Prevent contamination of the shallow groundwater by producer gas leaking past the borehole grouting by monitoring and maintenance as and when required;
- Remain within the guidelines and standards for ambient air quality, dustfall and emissions as summarised in sections 11.1.1 to 11.1.3 of this report. Wet suppression must be applied during construction. Air quality must be monitored and the mitigation measures described in 11.1.6 must be implemented;
- Keep off-site noise levels at identified receptors within the national standards and guidelines and avoid the exposure of any receptors to intrusive noise levels by applying the monitoring and mitigation measures described in section 11.2;
- Soften the visual impact of the project by applying the mitigation measures recommended in section 11.11 of this report;
- Rehabilitate the disturbed areas to a condition fit for grazing and the resumption of ecological function after project closure; and
- Protect the cultural and heritage resources described in section 7.11.3 of this report by appropriate fencing and education of personnel and contractors.

14.6.3 Rehabilitation requirements

Africary must seal off all boreholes and rehabilitate the project- affected areas on the surface to a self-sustaining state that is fit for grazing and the resumption of ecological function. Unless the powerline is required for beneficial use after project closure it must be removed and disturbed areas must be rehabilitated to a condition fit for grazing and the resumption of ecological function.

14.7 Period for which environmental authorisation is required

The planned perational life of the project is estimated to be 20 years. To accommodate the time needed for construction, UCG development, production ramp up, closure and rehabilitation, the authorisation is required for a period of 30 years.

14.8 Undertaking

It is confirmed that the undertaking required to meet the requirements of this section is provided at the end of the EMPr and is applicable to both the EIA Report and the EMPr Report

14.9 Financial Provision

The complete closure plan (Lagerwall, D; Brown, S A P;, February 2016), without financial amounts, is attached in APPENDIX H to this report. The amounts will be included in the report submitted to the DMR. The rehabilitation cost will be provided for from operating expenditure.
The approach to the determination of the closure costs can be summarised as follows:

- Background information, including aerial images, layout drawings and technical studies, was gathered from Africary;
- The battery limits and most likely closure situation were confirmed with Africary;
- Closure costs were determined for the scheduled closure situation only, as this will be a greenfield project and no site activities have taken place yet. The date for scheduled closure was taken as 2038;
- It was assumed that:
  - All infrastructure will be demolished and demolition waste disposed of off-site, the remaining footprint areas will be shaped and levelled so that they are free draining and the rehabilitated site will be returned to a state fit for grazing, consistent with the adjacent areas;
  - A third party contractor would undertake the closing, dismantling and rehabilitation-related work, i.e. market-related contractor rates were applied;
  - Demolition waste, such as concrete and building rubble, will be largely inert and that it will be disposed of at a registered landfill site;
  - All brine and PCD sediment will have been removed prior to decommissioning; and
  - Contaminated soils in the plant area, amounting to five percent of the total power plant site, will be collected and disposed of at a registered hazardous waste facility (Holfontein) prior to final rehabilitation of the site;
- Allowance was made for:
  - Care and maintenance as well as surface water monitoring to be conducted for a minimum period of 5 years to assess the success of the implemented rehabilitation and closure measures; and
  - Groundwater quality monitoring to be undertaken for a minimum period of 10 years to ensure no cross contamination of the shallow and lower aquifer has occurred and to monitor the lower aquifer for possible plume development.
- In accordance with the DMR guidelines, no cost off-sets due to possible salvage values were considered and only gross closure costs are reported; and
- Fixed ratios for Preliminary and General cooperating sts were applied in accordance with the DMR guidelines;

14.10 Deviations from approved scoping report and plan of study

There are no deviations from the scoping report and plan of study as submitted to the DMR on 5 November 2015.

14.11 Other information required by the DMR

14.11.1 Impact on socio-economic conditions of any directly affected person

Africary owns the farm Palmietkuil 548 where the preferred and alternative UCG target areas are located and on which the power generation plant and ancillaries will be established.

The most directly affected people will be the occupants of the farmsteads shown as sensitive receptors on Figure 7-7, Figure 11-1 and Figure 11-14. As discussed in section 11.0 and summarised in sections 12.0 and 13.1, they will experience a constant visual impact and may occasionally experience air quality conditions exceeding national standards for short periods during venting. Intrusive night-time noise levels may at times occur at the nearest farmsteads. A few local residents will obtain employment at the plant and learn knew skills. Some local businesses will supply Africary with goods and services.

14.11.2 Impact on any national estate

No impact is expected. The cultural and heritage specialist (see section 11.10 of this report and the complete specialist report in APPENDIX H) identified two graveyards, one situated about 300 m to the west of the plant site and the other situated approximately 20 metres from the shoulder of the dirt road where the electrical power line may run. The activities for which environmental authorisation is being sought will not affect either of the graveyards.

14.11.3 Other matters required in terms of section 24(4) of the NEMA

This section requires proof of compliance with section 24(4)(b)(i) of the National Environmental Management Act, which section reads as follows:

"24. Environmental authorisations

(4) Procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment -

(b) must include, with respect to every application for an environmental authorisation and where applicable-

(i) investigation of the potential consequences or impacts of the alternatives to the activity on the environment and assessment of the significance of those potential consequences or impacts, including the option of not implementing the activity;"

The specialist studies that investigated the potential impacts of the preferred project site and power plant route, as well as the alternatives, are attached to this EIA/EMPr Report - see APPENDIX H and their findings are described in section 11.0 of this report. The alternative power plant site, UCG target and power line routes were reasonable and feasible, albeit not preferred, for the reasons stated in sections 5.0 ,13.3 and 14.1 of this report.

PART B
ENVIRONMENTAL MANAGEMENT PROGRAMME REPORT

15.0 DRAFT ENVIRONMENTAL MANAGEMENT PROGRAMME

15.1 Details of Environmental Assessment Practitioner

See section 2.2 in Part A of this EIA/EMPr Report.

15.2 Description of the Aspects of the Activity

See sections 2.3,2.4,2.5 and 5.0 in Part A of this EIA/EMPr Report.

15.3 Composite Map

The map in Figure 15-1 shows the preferred and alternative power plant sites and transmission line routes superimposed on sensitive areas according to SANBI (South African National Biodiversity Institute) data.

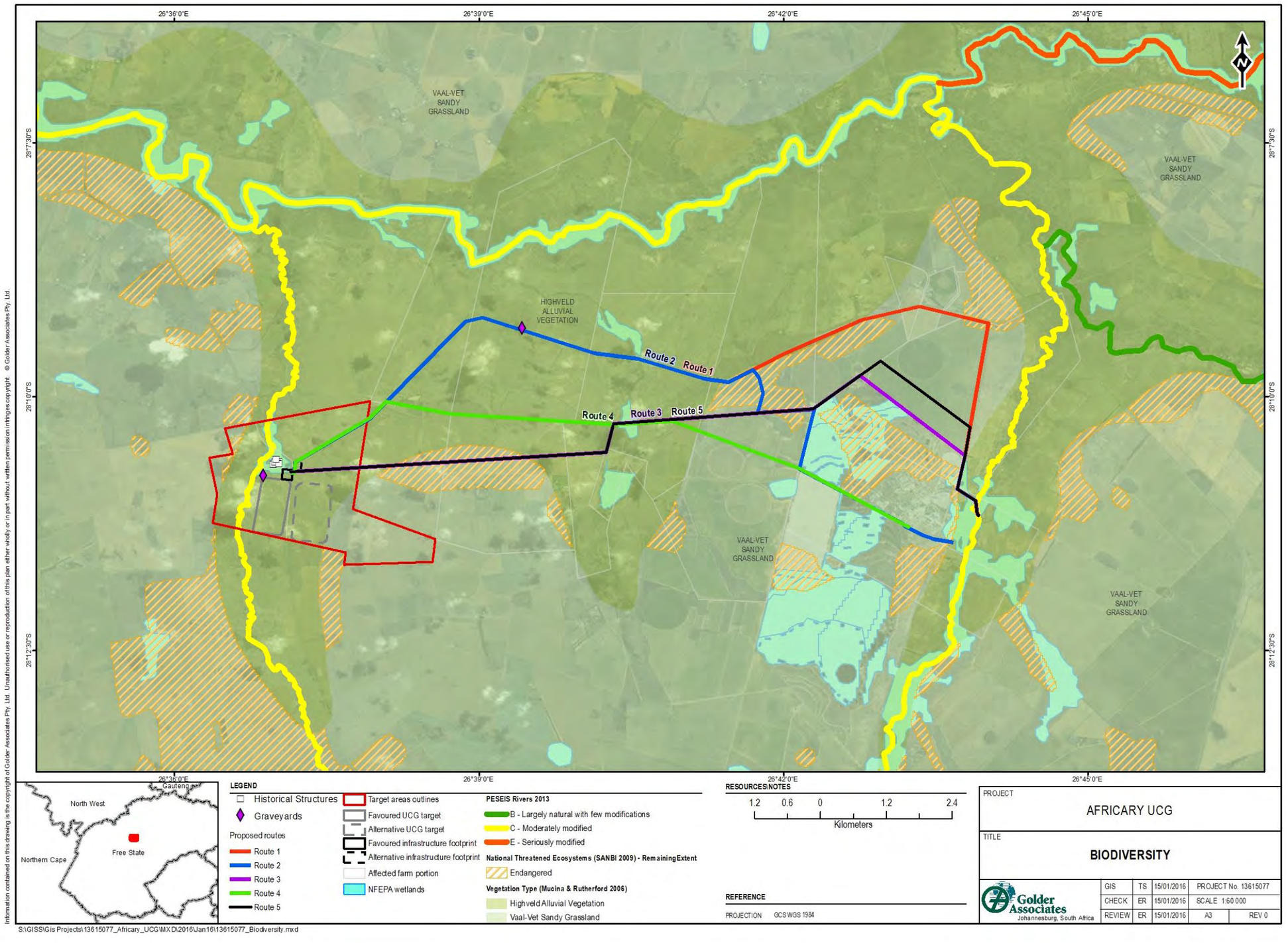


Figure 15-1: Composite map showing project components and sensitive areas

15.4 Impact Management Objectives and Statements

15.4.1 Determination of closure objectives

The current pre-project baseline environmental conditions were taken into account when the closure objectives described in section 16.2 of this report were formulated.

15.4.2 Environmental Quality and managing environmental impacts

Africary will apply the mitigation measures described in sections 11.0 and 15.5 to prevent adverse impacts on the local environmental quality during the construction, operational and closure phases of the project by possible physical effects and/or chemical contamination arising from the underground coal gasification (UCG) process and the surface operations of gas cleaning, power generation and waste management. After decommissioning, Africary will rehabilitate the power plant site (about 3 hectares) to a condition fit for grazing by:

- Applying all the mitigation measures described in this EMPr;
- Adhering to all the conditions stipulated in the environmental authorisation, waste management licence, atmospheric emission licence and water use licence;
- Monitoring atmospheric emissions, noise and quality of surface water and groundwater upstream and downstream of the project area;
- Controlling dust generation on the operational site and post-closure rehabilitated infrastructural area that could cause nuisance and/or health effects to surrounding landowners/communities;
- Conducting dedicated soil surveys over the footprint of the infrastructural site to identify and remove any possible pockets of contaminated soil that may have occurred;
- Cleaning up of any sources of possible soil contamination still present on the site to protect the downstream receiving environment;
- Monitoring groundwater quality and surface runoff for at least 5 years after closure, longer if warranted by the results; Target water quality objectives will be based on pre-closure groundwater and surface runoff quality up-gradient of the mining and ore processing activities.
- Providing the required measures to limit at source the generation of contaminants which could adversely affect local groundwater quality; and
- Ensuring that the respective rehabilitated areas are free-draining and that runoff is routed to local/natural drainage lines.

Unless the power line is required to remain in place for beneficial use, it will be removed and disturbed areas along the route will be rehabilitated.

15.4.3 Potential risk of acid mine drainage

As described in section 8.7.2 of the original EIA Report (Roux, E; Perry, E;, February 2014) and sections 7.5.2 and 11.7 of this report:

- The coal seam to be gasified is overlain by more than 330 metres of layered sandstone, mudstone and dolerite, which form an impenetrable barrier between the shallow aquifer (<50m from surface) and the very deep coal seam;
- The UCG process will be operated at a lower pressure than the hydrostatic pressure of the groundwater at the depth of the coal seam. Groundwater will gradually flow downward and into the gasifier and react with the coal to form syngas and there is no risk of contamination by mobilisation and transport of contaminants from the gasifier into the groundwater;

- Due to the low hydraulic conductivity of the geological formations surrounding the coal seam, the pre-UCG hydraulic head further away from the gasifier will remain unaffected and it will take about a decade for the gasifier to be filled by the inward flow of groundwater;
- After the gasifier has filled up with water, there will be very little to no flow of groundwater through the gasifier and no risk of significant contamination of groundwater further afield; and
- In contrast with conventional coal mining, there will be no waste or discard coal stockpiles, no ash stockpiles above ground, no risk of acid mine drainage and coal's most toxic elements – mercury, arsenic, and lead – remain underground.

15.4.4 Water use

Africary has applied for a water use licence to cover the water uses indicated in section 3.1.4 of this report.

15.5 Impacts to be mitigated and monitored in their respective phases

This section summarises the potential impacts of various aspects of the UCG project in all its stages, from construction, through operations to eventual decommissioning, together with the appropriate mitigation and monitoring measures to manage the identified impacts. Responsibilities for implementing the mitigation measures are identified and the frequencies with which the results of the various measures are to be monitored are stated. Additionally, Africary must submit environmental audits and performance reports as stipulated in the various authorisations.

The responsibility for monitoring and reporting the results to the appropriate level of management within Africary rests with the Environmental Control Officer (ECO).

Note:
This section can be printed and used as a field guide during each phase of the project

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
CONSTRUCTION PHASE								
11.1.6.1	Air Quality as affected by particulate mobilisation during site preparation, earthmoving and digging of foundations	Dust fall, PM_{10} and exhaust fumes	To remain within national standards at site perimeter and at sensitive receptors	See sections 11.1.2 and 11.1.3 of this report	Dust fall will be monitored by dust collection buckets installed downwind of the construction area. Monitoring will be done in accordance with SANS 2004. Wet suppression will be applied sparingly, to ensure the absence of visible dust; Enforcement of low vehicle speeds on unpaved roads (< 30 km/h); Ensuring that all equipment is well maintained and in good working order; Switching equipment and vehicles off when not in use; Minimising the area disturbed at any one time; Avoiding the use of unsealed roads where possible; and The disturbed areas will be vegetated with locally indigenous grass species as soon as possible	Africary, ECO, Contractors	Weekly, for duration of construction activities (12-15 months)	
11.2.2.1	Noise generated by earthmoving, erection of buildings and other infrastructure and installation of equipment	Construction activities are not likely to exceed standards or reach intrusive levels at any identified noise sensitive areas and the impact on the public will also be limited by the relatively short duration of the construction period. However, the construction workers will be exposed to relatively high noise levels.	To remain within the guidelines provided in section 11.2.1 of this report	No exceedance of guidelines. No complaints from receptors	Equipment with lower sound power levels will be selected preferentially; Fans will be equipped with silencers; Engine exhausts and compressor components will be equipped with suitable mufflers; Acoustic enclosures will be used for equipment causing radiating noise; and The wearing of hearing protection equipment will be mandatory in areas where noise levels are ≥ 85 dBA.	Africary, ECO, Contractors	At commencement of noisy construction activities, thereafter upon receipt of complaints	
11.3.1	Topography	Minor topographical changes due to construction of water management systems, office and workshops	No unnecessary topographical changes	Unavoidable topographic changes only	Design of site layout	Africary, ECO, Contractors	Monthly, for duration of construction activities (12-15 months)	
11.4.1	Geology	Minor disturbance of near-surface geology and lithology. Drilling of injection and production wells will take place through all strata down to about 350 metres, but the geological disturbance will not extend beyond the diameter of each borehole.	No unnecessary geological impact	Unavoidable geological impacts only	None	Africary, ECO, Contractors	Weekly, for duration of construction activities (12-15 months)	
11.5.1	Soil, land use and land capability as affected by site preparation and construction activities	Loss of topsoil, mixing with subsoil and contamination by spillages of cement, fuel and lubricants; and Colonisation of the stockpile and disturbed areas along the power line and pipeline route by weeds.	Preservation of all topsoil stripped from construction areas	No loss of topsoil quantity or quality	Drip trays will be placed under vehicles that are parked on unpaved areas for more than 3 hours; Cement and concrete will be mixed in appropriate equipment or on mortar boards, not on open ground;	Africary, ECO, Contractors	Weekly, for duration of construction activities (12-15 months)	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
					Spillages of hydrocarbons and/or cement will be cleaned up immediately and the contaminated soil will be either remediated *in situ* or disposed at an appropriately licensed landfill site Topsoil will be stripped carefully to avoid mixing with subsoil and used to construct the clean runoff diversion berm; Topsoil and subsoil will be stockpiled separately; The height of the stockpile will be limited to 3 metres and the slope to 1 in 4, and the top edges will be rounded; The stockpile, diversion berm and disturbed soil along the power line and pipeline route will be kept moist and vegetated with locally indigenous grass species; The stockpile, the berm and the power line and pipeline route will be weeded regularly.			

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
11.6.5.1	Surface water	Construction activities could lead to runoff with high silt load and contaminants such as fuel, hydraulic fluids, degreasing and other chemicals and cement	No pollution of water courses	No change in surface water quality downstream of site	Clean water diversion berms and channels will be constructed first, before undertaking any other activities; The bund walls and walls of the brine ponds will be raised at least one metre above ground level to prevent flooding by runoff during heavy rain. Construction will take place under the supervision of a qualified professional engineer for quality control, with special reference to the integrity of the pond liners and the bunds; Construction will preferably take place during the dry season (May to September); Drip trays will be placed under parked vehicles; Vehicles will be serviced in a workshop, not in the field; If in-field refuelling is done from a tanker, it will be done in a designated dirty area and a spill kit and clean-up team will be available on site; and Spillages will be cleaned up immediately and contaminated soil will either be remediated *in situ* or disposed of at an appropriately licensed landfill site.	Africary, ECO, Contractors	Weekly, for duration of construction activities (12-15 months)	
11.7.1	Groundwater	Contamination of groundwater through spillages of fuels, lubricants, hydraulic fluids and chemicals, and by poor sanitation practices of construction workers	No contamination of groundwater	No change in groundwater quality	Shallow aquifer boreholes BH2, BH3 and BH1 will be monitored with regard to water levels and water quality on a monthly basis; Drip trays will be placed under vehicles when parked; Vehicles will be serviced in a workshop, not in the field; If in-field refuelling is done from a tanker, it will be done in a designated dirty area and a spill kit and clean-up team will be available on site; Spillages will be cleaned up immediately and contaminated soil will either be remediated in situ or disposed of at an appropriately licensed landfill site; Adequate sanitation facilities will be provided in the form of chemical toilets that are serviced regularly; and All workers on site will undergo environmental awareness training.	Africary, ECO, Contractors	Weekly, for duration of construction activities (12-15 months)	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
11.8.1	Terrestrial ecology as affected by site preparation and construction activities	Stripping of vegetation from an area of about 2 ha on the power plant site and from a 2 metre wide strip along the pipeline route Human presence and construction noise are likely to drive most species of fauna away.	Minimisation of ecological impact	Vegetation stripped only where essential; No avoidable harm to fauna	Site layout will be planned to minimise ecological disturbance; Laydown and construction areas will be demarcated; Trees that are not to be removed will be clearly marked with barrier tape; Designation of no-go areas, e.g. the riparian areas of the Palmietkuilspruit and the area on the alternative site where the small geophytes grow; Africary's staff and construction personnel will receive training in environmental awareness and the recognition of Red Data species. If any Red Data species are found, the services of a suitable specialist will be sourced to advise on their safety and whether relocation is required; There will be strong sanctions against the hunting, trapping, killing or otherwise harming of all species; All geophytes within the affected footprint will be relocated to suitable habitat by a properly qualified person prior to the commencement of construction activities; Vehicle movement will be restricted to existing roads and farm tracks; Dust will be controlled by wet suppression; All disturbed area will be re-vegetated with locally indigenous species; and The construction activities will be monitored and audited for compliance with the EMPr. After installation of the pipeline and power line, the route will be inspected quarterly until the construction disturbances have been appropriately rehabilitated.	Africary, ECO, Contractors	Weekly, for duration of construction activities (12-15 months)	
11.9.1	Socio-economics	Construction phase will involve 150 to 200 workers (< 0.25% of the unemployed in the district) for 12 to 15 months, capital expenditure of about R1.5 billion (< 1% of regional GDP) with about 20%local content.	To minimise negative and enhance positive impacts	No complaints from local residents; Neutral to positive attitude towards project	Expectations of employment and other socio-economic benefits will be managed carefully through effective communication with local communities; Where practicable and economically feasible, local contractors will be given preference, and goods and services will be sourced from local suppliers; Creating and maintaining a communication channel (name, phone and fax number, e-mail) that members of the public can use to lodge complaints, pose questions and ask for information. A complaints register will be created and maintained, following up on every complaint and providing responses until the complaint is closed out.	Africary, ECO, Contractors	Monthly, for duration of construction activities (12-15 months)	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
					Local community skills development will be included as part of the social and labour plan (SLP).			
11.10.1	Cultural and heritage resources	No impact on the two identified graveyards, but possibility of unearthing unknown graves or other buried cultural/archaeological items cannot be ruled out	To avoid causing adverse impacts on any archaeological, cultural and heritage resources	Minimal or no adverse impact on any archaeological, cultural and heritage resources	The two identified sites will be clearly demarcated as no-go zones and the following chance find procedures will be implemented: ▪ All work in the immediate vicinity of the find will cease; ▪ The area will be demarcated with barrier tape or other highly visible means; ▪ The South African Heritage Resources Authority (SAHRA) will be notified immediately; ▪ An archaeologist accredited with the Association for Southern African Professional Archaeologists (ASAPA) will be commissioned to assess the find and determine appropriate mitigation measures, which may include obtaining the necessary authorisation from SAHRA to undertake the mitigation measures; and ▪ Access to the find by unqualified persons will be prevented until the assessment and mitigation processes have been completed.	Africary, ECO, Contractors	Monthly, for duration of construction activities (12-15 months)	
11.11.1	Visual aspects as affected by site preparation and construction activities	Generation of visible dust by vegetation clearing, excavation activities and vehicles travelling over unpaved surfaces. Night-time visual impact due to security lighting and headlights of vehicles	To minimise visual impact during construction phase	No visible dust No nuisance lighting at night	Dust suppression with water or chemical binders; Limiting vehicle movement at night: and Installing motion-sensitive lighting that is directed downwards and inwards towards the site	Africary, ECO, Contractors	Monthly, for duration of construction activities (12-15 months)	
General	Dangerous activities	Worker safety	To maintain safe work practices in a safe environment and to avoid personnel injuries and damage to assets	Documentation of all unplanned incidents and achievement of target safety performance statistics	Toolbox talks/staff briefing sessions Site workers training programme Training in the use and handling of equipment	Africary, ECO, Contractors	Weekly, for duration of all project activities, all phases	
OPERATIONAL PHASE								
11.1.6.2	Air Quality as affected by emissions from the power plant during operation	Under normal operating conditions emissions from the power plant will not affect air quality significantly. Venting could raise ambient CO levels to 50% of the one-hour South African standard over a substantial area and up to 80% of the standard in a few small spots some 5 km to the south and south-south-east of the	Meeting of AQ standards and guidelines; No health risk or nuisance impact to sensitive receptors;	See sections 11.1.2 and 11.1.3 of this EIA/EMPr report No complaints	Where possible, venting will be done only under good conditions for dispersion (during summer change of season winds) Inversion conditions during winter will be avoided; Flaring will be done only when necessary, and as briefly as possible; If possible flaring at night will be avoided, especially during winter; and Raw gas will be cleaned to remove particulate matter and higher	Africary, ECO, Consultants and Contractors	Weekly, for duration of operational activities (up to 20 years)	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
		power plant site Flaring could raise ambient SO_2 levels to 50% of the one-hour South African standard over a fairly large area and up to 70% of the standard in a few small areas some 5 km to the south and south-south-east of the power plant site. Venting and flaring are expected to be rare events of short duration.			hydrocarbons before the gas is used in the reciprocating engines; The following good practice measures will also be implemented as far as practicable: ▪ The gas engine exhaust stack will have a height of at least 15m; ▪ Application of control technologies to the gas engine exhaust emissions, which may include: non-selective catalytic reduction (NO_x and CO)and catalytic oxidation (CO) Stack monitoring will be implemented in line with AEL requirements.			
11.2.2.2	Noise generated mainly by operation of power plant	Although noise standards at noise sensitive areas (farm dwellings) would not be exceeded, a gas turbine plant would be audible at all the NSAs, may lead to complaints from residents at NSA 7 and 8, and would probably be experienced as unacceptably intrusive at NSA1. Gas engines would generate a night-time intrusive level only at NSA 1	To avoid exceedances of national standards and intrusive noise levels at sensitive receptors	See section 11.2.1 of this EIA/EMPr report No intrusive noise levels experienced by sensitive receptors No complaints from local residents	Use of gas engines instead of gas turbines; Selecting engines with lower sound output levels and equipped with appropriate exhaust mufflers; The engines will be enclosed in a building that has been properly designed and built to reduce the level of noise at source; The wearing of hearing protection equipment will be mandatory in areas where noise levels are ≥ 85 dBA. A screen of fast-growing indigenous trees and other vegetation will be planted around the perimeter of the site, especially on the north-western side; A public communication channel (name, phone and fax number, e-mail) will be created and maintained. A complaints register will be created and maintained, every complaint will be followed up and responded to until the complaint has been closed out.	Africary, ECO, Consultants and Contractors	When plant comes into full operation, thereafter when complaints are received, for duration of operational activities (up to 20 years)	
11.3.2	Topography may be affected by goafing over the long term	Goafing will take place after the coal has been consumed and this may lead to surface subsidence, which is likely to be in the region of 1.0 to 1.2 metres.	To avoid disturbing surface topography	No or minimal disturbance of surface topography	Unlikely to be required	Africary, ECO, Consultants and Contractors	Annually, for duration of operational activities (up to 20 years)	
11.4.2	Geology	The consumption of the coal in the seam will alter the geology permanently and irreversibly within each UCG gasifier	To limit geological disturbance to that which is unavoidable due to the nature of UCG	No unnecessary disturbance of geology	Every effort will be made to utilise all the gas generated by UCG, and to flare as little possible; Regular monitoring for gas leaks at the injection and production boreholes	Africary, ECO, Consultants and Contractors	Weekly, for duration of operational activities (up to 20 years)	
11.5.2	Soils, land capability and land use – possible contamination from spillages	The operational phase will not involve any further disturbance of the soil, but there will be a potential for soil pollution due to spillages of hydrocarbons, hydraulic fluids, brine and process chemicals	To avoid soil contamination due to operational activities	No contamination of soil	All hydrocarbons, hydraulic fluids and liquid process chemicals will be stored in bunded areas, each of which will have the capacity to contain the contents of the largest vessel within the bund plus ten per cent; All machinery will be serviced in	Africary, ECO, Consultants and Contractors	Monthly, for duration of operational activities (up to 20 years)	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
					workshops or *in-situ* in the power plant; Vehicles will be parked and washed on impervious surfaces that drain into the grey water collection system; Paint, cleaning fluids and solid process chemicals will be stored in buildings with concrete floors and access control; and Any spillages that may occur will be cleaned up immediately.			
11.6.5.2	Surface water	Contamination of surface water possible *via* leakage of bunds and/or brine ponds, overflow of bunds and/or brine ponds, and storage of process chemicals and/or wastes outside of bunded areas. Contamination of shallow aquifer by leakage of gas from underground gasifier past borehole casings and grouting seals could migrate into the surface water resources.	To avoid contamination of surface water resources	No deterioration of water quality in Palmietkuilspruit due to Africary activities	Monthly monitoring of the water in the Palmietkuilspruit as stipulated in section 11.6.5.2 of this EIA report; Monthly inspection of the clean water diversion channels, clearing them of obstacles to ensure free flow and maintaining them in a good state of repair; Implementation of all the mitigation measures against groundwater impacts described in section 11.7.2.	Africary, ECO, Consultants and Contractors	Monthly, for duration of operational activities (up to 20 years)	
11.7.2	Groundwater may potentially be contaminated by underground coal gasification process	Cross-contamination between shallow and deep aquifers that are separated by geological formations with low permeability can occur due to inappropriate borehole construction, which would allow fugitive syngas to migrate into the shallow aqufer.	No contamination of local groundwater resources	No deterioration of water quality in monitoring boreholes	All exploration boreholes into the coal seam will be hermetically sealed with concrete or grouting mix; Drilling of the injection and production boreholes will be undertaken by a specialist drilling contractor with adequate experience of gas or oil drilling and a proper understanding of the required casing and grouting specifications; The pressure in the gasifier will be monitored continuously and the rate of gasification will at all times be controlled to maintain the pressure in the gasifier at a lower level than the hydraulic pressure in the surrounding geological formations; and At the end of the life of a gasifier, the disused injection and production boreholes will also be hermetically sealed with concrete or grouting mix.	Africary, ECO, Consultants and Contractors	Monthly, for duration of operational activities (up to 20 years)	
11.8.2	Terrestrial Ecology	Operational activities are unlikely to have adverse effects on vegetation on and in vicinity of power plant site and power line route. Minor disturbances possible when drilling new injection and production wells. Constant human presence and noise generation will keep most fauna away.	To avoid any unnecessary impacts on terrestrial ecology in vicinity of site and power line route	No further ecological impacts in vicinity of site and power line route	Weeds and invasive flora will be monitored and controlled as per the legal requirements of the CARA; All personnel be trained in environmental awareness and the recognition of Red Data species. If any Red Data species are observed, the services of a suitable specialist will be sourced to advise on their safety and whether relocation is required; No-go areas will be designated, e.g. the riparian areas of the Palmietkuilspruit and the area on the alternative site where the small geophytes grow;	Africary, ECO, Consultants and Contractors	Monthly, for duration of operational activities (up to 20 years)	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
					There will be strong sanctions against the hunting, trapping, killing or otherwise harming of all species; Vehicle movement will be restricted to existing roads and farm tracks; Dust will be controlled by wet suppression;			
11.9.2	Socio-economics	The operations phase will employ 10 people on day shift and 5 people on night shift. The power output of 50 - 60 MW will add about 0.125% to the national power generation capacity. The estimated annual operating cost of about R300 million, is less than 0.2% of the regional GDP	To maximise the socio-economic benefits for people in the region	Enhanced regional socio-economic benefits	Goods and services will be purchased locally and local people will be employed as far as practicable; The SLP will focus on skills development and establishing sustainable community projects The current project should be viewed as a demonstration project that could lead to safer, more economical and more environmentally friendly means of utilising some of the country's coal resources.	Africary, ECO, Consultants and Contractors	Monthly, for duration of operational activities (up to 20 years)	
11.10.2	Cultural and heritage resources	Unlikely to occur – there is no reason for the project operations to affect the identified heritage resources adversely	To avoid causing adverse impacts on any archaeological, cultural and heritage resources	Minimal or no adverse impact on any archaeological, cultural and heritage resources	All personnel will undergo awareness training; A fence with a lockable gate will be erected around GY01; There will be strict sanctions against damaging any of the resources; Any damage that may occur will be repaired; and Where practical, historical structures will be occupied and maintained for beneficial use.	Africary, ECO, Consultants and Contractors	Monthly, for duration of operational activities (up to 20 years)	
11.11.2	Visual aspects	The power plant will be visually prominent due to large, tall structures, flaring (especially at night) and possibly dust generation from unpaved surfaces. Lighting will be visually intrusive at night.	To minimise visual impact during operational phase	No visible dust No nuisance lighting at night No complaints	Bright, shiny, reflective surfaces such as galvanised steel cladding will be avoided. Surfaces will be painted in matt pastel colours that blend in with the background; A screen of indigenous trees will be planted and maintained around the perimeter of the power plant site; The lighting requirements of the facilities will be designed to provide lighting that meets operational requirements without resulting in excessive illumination; Zones of high and low lighting requirements will be identified, with the focus on illuminating areas to the minimum extent required to allow safe operations at night and for security purposes; Lighting will be directed inwards, downwards and, where possible, away from the local roads and farmhouses; The height from which floodlights are fixed will be as low as possible while still maintaining the required levels of	Africary, ECO, Consultants and Contractors	Monthly, for duration of operational activities (up to 20 years)	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
					illumination; Up-lighting of structures will be avoided by directing lighting downwards and focused on the area to be illuminated; Flaring at night will be avoided if possible; and Access road to and bare areas on the plant site will be paved.			
CLOSURE AND REHABILITATION PHASE								
11.2.2.3	Air quality as affected by site rehabilitation activities	Similar activities and impacts as the construction phase, but shorter duration. Monitoring and maintenance will continue for at least five years, will not have any significant impacts	To remain within national standards at site perimeter and at sensitive receptors	See sections 11.1.2 and 11.1.3 of this EIA/EMPr report	Wet suppression will be applied sparingly to ensure the absence of visible dust; Low vehicle speeds (≤ 30 km/h) will be enforced on unpaved areas; Only well maintained equipment in good working order will be used; Equipment and vehicles will be switched off when not in use; The use of unsealed roads will be avoided where possible; and The disturbed areas will be re-vegetated with a locally indigenous grass species as soon as possible.	Africary, ECO, Contractors	Weekly, for duration of rehabilitation activities, thereafter monthly until self-sustaining vegetation cover has been established	
11.2.2.3	Noise generated during site decommissioning and rehabilitation activities	Similar activities and impacts as the construction phase, but shorter duration and lesser extent, involving fewer vehicles and machines. Workers may be exposed to relatively high noise levels. Greatly reduced noise levels after 3 to 4 months, when only monitoring and maintenance is done	To remain within the guidelines provided in section 11.2.1 of this EIA/EMPr report	No exceedance of guidelines. No complaints from receptors	Equipment with lower sound power levels will be selected preferentially; Fans will be equipped with silencers; Engine exhausts and compressor components with suitable mufflers will be used; and Acoustic enclosures will be used for equipment causing radiating noise; and The wearing of hearing protection equipment will be mandatory in areas where noise levels are ≥ 85 dBA.	Africary, ECO, Contractors	Once, when noisy activities have commenced, thereafter upon receipt of complaints	
11.3.3	Topography	Removal of infrastructure, in-filling of brine pond and PC dam basins and landscaping to restore original drainage lines will return topography to original state. Surface subsidence due to goafing may occur, but is unlikely to be significant.	To restore the original topography of the project area	Post-rehabilitation topography closely matches original topography	No additional mitigation measures are likely to be required.	Africary, ECO, Contractors	Weekly, for duration of rehabilitation activities	
11.4.3	Geology	The closure and rehabilitation phase will not have any effect on the geology of the area	No impacts on geology	No impacts on geology	No mitigation measures necessary	Africary, ECO, Contractors	No monitoring necessary	
11.5.3	Soil, land capability and land use	Without careful placement of topsoil during closure and rehabilitation of the brine ponds, significant loss of soil quality may occur as due to mixing with subsoil and overburden, contamination with hydrocarbons and hydraulic fluids, erosion and weed infestation	To restore the soil in the disturbed areas as close to its original condition as practicable	Soil function restored to a condition that will support self-sustaining indigenous vegetation	The basins will be filled with subsoil and profiled to be free draining; The topsoil will be spread over the subsoil; Light agricultural machinery will be used avoid compaction of the topsoil; The soil will be sampled and analysed after placement and nutrients (compost and fertiliser) will be added as advised by	Africary, ECO, Contractors	Weekly, for duration of rehabilitation activities, thereafter monthly until self-sustaining vegetation cover has been established	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
					a qualified agronomist; The affected areas will be re-vegetated with locally indigenous grass, forb, shrub and tree species under the direction of a qualified botanist; and Rehabilitation progress will be monitored quarterly until the vegetation becomes self-sustaining. Any erosion rills that may have developed will be repaired and, if any bare patches larger than 4 m^2 are found, they will be re-vegetated after investigating the reasons and taking remedial action.			
11.6.5.3	Surface water	Decommissioning activities will be similar to those undertaken during the construction phase and could also lead to runoff with a high silt load and contaminants such as fuel, hydraulic fluids, degreasers and other chemicals.	Clean runoff along original drainage lines	No contamination of surface water resources; No complaints	The clean water diversion berms, dirty water collection channels and brine ponds will be the last structures to be demolished; Drip trays will be placed under vehicles when parked; Vehicles will be serviced in a workshop, not in the field; If in-field refuelling is done from a tanker, it will be done in a designated dirty area and a spill kit and clean-up team will be available on site; Spillages will be cleaned up immediately and contaminated soil will either be remediated *in situ* or disposed of at an appropriately licensed landfill site; Compacted areas will be ripped. The soil will be sampled, analysed and appropriately fertilised; Rehabilitation areas will be shaped to be free draining; and Disturbed areas will be re-vegetated with locally indigenous grasses, shrubs and trees.	Africary, ECO, Contractors	Weekly, for duration of rehabilitation activities, thereafter quarterly until self-sustaining vegetation cover has been established	
11.7.3	Groundwater	Changes in natural groundwater flow and recharge due to changes in stratigraphy, geological and soil conditions caused by the mining and backfilling operations. Groundwater may be at more risk of contamination due to increased hydraulic conductivity;	No contamination of local groundwater resources	No deterioration of water quality in monitoring boreholes	Drip trays will be placed under parked vehicles; Vehicles will be serviced in a workshop, not in the field; If in-field refuelling is done from a tanker, it will be done in a designated dirty area and a spill kit and clean-up team will be available on site; Spillages will be cleaned up immediately and contaminated soil will either be remediated *in situ* or disposed of at an appropriately licensed landfill site; All workers on site will receive environmental awareness training; and Water levels and water quality of shallow aquifer boreholes up-gradient and down-gradient of the power plant site will be monitored monthly until demolition	Africary, ECO, Contractors	Weekly, for duration of rehabilitation activities, thereafter quarterly until lack of significant residual impact has been demonstrated	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
					activities have been completed and three-monthly for three years thereafter			
11.8.3	Terrestrial Ecology	Ecological quality of degraded vegetation currently on site could deteriorate further If rehabilitation is not undertaken correctly, if soil pollution occurs during closure and if the disturbed soil is colonised by weeds and alien invader species.	To establish locally indigenous vegetation on areas disturbed by the project	Self-sustaining biodiverse indigenous vegetation on all areas disturbed by the project	Steel structures will be removed, brick and concrete structures will be demolished, building rubble will be removed and disposed of in accordance with applicable regulatory requirements; The sediment and liner will be removed from the PC dam, the brine and liners from the brine ponds, and disposed of appropriately. Any spillages will be cleaned up immediately and any contaminated soil will be disposed of in accordance with applicable regulatory requirements; All weeds and alien plants will be removed from the site; Compacted areas will be ripped and the surface of the site will be shaped to be free draining. Stockpiled subsoil will be spread first, then topsoil that has been preserved in the storm water diversion berm and the topsoil stockpile. Care will be to taken avoid mixing of subsoil with topsoil. Light agricultural machinery will be used to avoid compaction; Soil will be analysed and soil conditioners and fertilisers will be added as recommended by a qualified soil scientist; The affected areas will be re-vegetated with locally indigenous grasses, shrubs and trees to encourage colonisation by fauna; Rehabilitation progress will be monitored quarterly until the vegetation becomes self-sustaining. If any bare patches develop, the reason will be investigated and addressed, followed by re-vegetation of the patch.	Africary, ECO, Contractors	Weekly, for duration of rehabilitation activities, thereafter monthly until self-sustaining vegetation cover has been established	
11.9.3	Socio-economics	Similar, but smaller positive socio-economic impacts than during construction phase	To minimise negative and enhance positive impacts	Socio-economic impact acceptable to personnel and local communities	Skills development and training of employees to enhance their value in the labour market and thereby their chances of finding employment after mine closure; Development of a retrenchment plan in consultation with employees, starting at least five years before closure; Assisting redundant employees to find alternative employment as far as practicable; Focusing specifically on sustainable community projects in the SLP, i.e. projects that will remain viable without continued support from Africary; Leaving intact such infrastructure as can be used by local communities, after	Africary, ECO, Contractors	Monthly, for duration of rehabilitation activities	

NO	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Frequency and Timeframe	For Monitoring Purposes only – Successfully Implemented / Corrective action required (To be completed by ECO)
					consultation with the communities;			
11.10.3	Cultural and heritage resources	The closure and rehabilitation phase should have no impact on any identified cultural and heritage resources.	To avoid causing adverse impacts on any archaeological, cultural and heritage resources	Minimal or no adverse impact on any archaeological, cultural and heritage resources	It is not expected that any mitigation measures will be required.	Africary, ECO, Contractors	Monthly, for duration of rehabilitation activities	
11.11.3	Visual aspects	Generation of visible dust by surface ripping and profiling activities and vehicles travelling over unpaved surfaces. Night-time visual impact due to security lighting and headlights of vehicles	To minimise visual impact during rehabilitation phase	No visible dust No nuisance lighting at night	Maintenance of an effective tree screen; Dust suppression with water or chemical binders; Limiting vehicle movement at night: and Making use of motion-sensitive lighting that is directed downwards and inwards towards the site	Africary, ECO, Contractors	Monthly, for duration of rehabilitation activities	

16.0 FINANCIAL PROVISION

16.1 Overall Closure Goal

The overall closure goal for the proposed underground coal gasification (UCG) project is to leave behind a safe, stable and non-polluting project area that is fit for grazing and bears a good resemblance to the current appearance of the area.

16.2 Closure Objectives

The above closure goal is underpinned by the more specific objectives listed below. These objectives are stated qualitatively and will become more specific as the more detailed closure measures are devised during the life of the project. The objectives apply to the project site in its final closed state and not while it is in progress towards this state. The closure goal and objectives were developed in consultation with Agricary Farming (Pty) Ltd, the owner of the farm Palmietkuil 548.

16.2.1 Physical Stability

To facilitate the implementation of the planned land use, by:

- Closing, dismantling, removing and disposing of all surface infrastructure that has no beneficial post-closure use;
- Ripping, shaping, and vegetating of reclaimed footprint areas as well as access roads with no beneficial post-closure use and integrating these into the surrounding areas; and
- Sealing all project boreholes except those drilled for monitoring of the shallow aquifer.

16.2.2 Environmental Quality

To ensure that local environmental quality is not adversely affected by possible physical effects and chemical contamination arising from the project area by:

- Limiting dust generation on the rehabilitated infrastructural areas that could cause nuisance and/or health effects to surrounding landowners/communities;
- Conducting dedicated soil surveys over the footprint of the infrastructure site and removing any identified pockets of contaminated soil;
- Cleaning up of any sources of potential soil contamination present on the site to protect the downstream receiving environment; and
- Ensuring that the rehabilitated site is free-draining and runoff is routed to local/natural drainage lines as far as possible.

16.2.3 Health and Safety

To limit the possible health and safety threats to humans and animals using the rehabilitated site by:

- Removing, for safe disposal, all potential process-related contaminants to ensure that no hazardous waste is present on the mine site once it has been rehabilitated;
- Demonstrating by means of suitable sampling and analysis that the threshold levels of salts, metals and other potential contaminants over the rehabilitated site in terms of the long-term land use planning for human and animal habitation are acceptable;
- Demonstrating through a review of monitoring data that no possible surface and/or groundwater contaminant sources remain on the rehabilitated site that could compromise the planned land use and/or pose health and safety threats; and
- Monitoring environmental performance as set out in section 15.5 of this report.

16.2.4 Land Capability/Land-use

To re-instate suitable land capabilities over the affected site to facilitate the progressive implementation of the planned land use, by:

- Zoning of the project area and obtaining agreement with stakeholders on this;
- Upfront materials balancing and handling to ensure that the soil types are stockpiled separately and subsequently placed, during site rehabilitation, to allow the desired land capability and end land use to be achieved; and
- Re-vegetating the project-affected area with a mix of locally indigenous grass and forb species with the objective of rendering it fit for grazing.

16.2.5 Aesthetic Quality

To leave behind a rehabilitated infrastructure site that, in general, is not only neat and tidy, giving an acceptable overall aesthetic appearance, but which in terms of this attribute is also aligned to the respective land use, by:

- Tidying-up the site by removing demolition waste, rubble, etc.;
- Shaping and levelling disturbed areas to create landforms that emulate the surrounding surface topography and would facilitate drainage;
- Re-establishing vegetation on the above areas to be self-sustaining, ecologically functional and aesthetically pleasing.

16.2.6 Biodiversity

To encourage the re-establishment of locally indigenous vegetation on the rehabilitated areas such that the terrestrial biodiversity is largely re-instated over time, by:

- Stabilising disturbed areas to prevent erosion in the short to medium term until a suitable vegetation cover has established;
- Establishing viable self-sustaining vegetation communities that will encourage the re-introduction of local fauna as far as possible;
- Identifying those aspects/obstacles once site rehabilitation has been completed which could inhibit and/or deter animal life from returning to the rehabilitated site; and
- Removing the identified obstacles without compromising the adopted final land use.

16.2.7 Socio-economic Aspects

To ensure that any infrastructure transfers, measures and/or contributions made by the project towards the long-term socio-economic benefit of the local communities are sustainable, by:

- Identifying buildings and other infrastructure that could be of commercial and/or other value/benefit to the local community and transferring these to third parties as agreed between Africary and these parties and/or the stakeholders;
- Communicating and negotiating with local communities and related civil structures on the closure of the project and the possible transfer of surface infrastructure to them;
- Ensuring effective hand-over of pre-determined project-related surface infrastructure for future use by other parties;
- Providing, until hand-over of the project-related surface infrastructure, training and awareness creation to empower the communities to effectively manage the financial and/or commercial resources transferred from the mine; and
- Clearly defining the roles of the parties responsible for future management of transferred facilities.

The above closure goals and objectives were developed to restore baseline conditions as far as practically and economically achievable. The mitigation and rehabilitation measures described in sections 11.0 and 15.4 to 15.5 of this report are specifically aligned to the closure goals and objectives stipulated in sections 16.1 and 16.2 of this report.

The quantum of the financial provision has been calculated and is shown in detail in the complete closure report that will be submitted to the DMR.

16.3 Closure costing

16.3.1 Assumptions

The following key assumptions were made with respect to plugging/isolation of the gasifier:

- There will be three production wells and four injection wells, approximately 320 - 500m deep, with a diameter of about 216 mm; and
- The planned size of the gasifier is about 100 ha and the average coal seam thickness is 3.2 m, i.e. the volume of the gasifier will be about 3 200 000 m³, but some of the space will be occupied by ash, condensate and rubble due to caving in of the layers immediately above the gasifier (goafing). With significant goafing over time most of the spent gasifier would be filled with rubble. From the geology as determined from the prospecting boreholes, the rubble is expected to contain from 25% to 40% of clay minerals such as kaolinite and microcline and the material in the spent gasifier is expected to have a permeability of 3% to 10%.

16.3.2 Closure cost scenarios and estimates

The bill of quantities was obtained from available plans and maps supplied to Golder. Unit rates were obtained from Golder's database and/or in consultation with demolition practitioners. The closure costs were determined for scheduled closure after 20 years.

As discussed in section 11.7.2, after the gasifier has filled up with water, there will be very little to no flow of groundwater through the gasifier and negligible risk of significant contamination of groundwater further afield. Accordingly, no allowance was made in the costing to seal the gasifier.

16.3.2.1 Annual rehabilitation and scheduled closure cost

The closure costs were calculated in accordance with GN R.1147, the *Regulations Pertaining to the Financial Provision for Prospecting, Exploration, Mining or Production Operations*, which commenced on 20 November 2015. These regulations require estimation of the following:

- Cost for annual rehabilitation to be undertaken within the first 12 months of operations;
- The scheduled closure cost at the end of the life of the operations; and
- Cost associated with the latent or residual environmental impacts which may become known in the future as reflected in the environmental risk assessment approach.

16.3.2.2 Latent risk closure costs

Latent environmental risks are covert or dormant and could manifest over time. They are often difficult to predict and to cost. The potential latent risks identified from the available information and specialist studies undertaken are listed in Table 16-1.

Table 16-1: Latent environmental impacts/risks

Latent impact /risks	Reasoning for latent impact	Probability of occurrence	Mitigation measures
Contaminated water that has accumulated within the spent	■ Due to very low permeability of geological formations in UCG area,	Very low	■ Undertake groundwater quality monitoring of the gasification cavities as they refill to quantify

Latent impact /risks	Reasoning for latent impact	Probability of occurrence	Mitigation measures
gasifiers could, once groundwater levels have re-established, migrate from these cavities and pollute the surrounding deep aquifer.	groundwater movement is expected to be very slow after re-establishment of pre-development levels. ■ Limited movement of contaminated water into surrounding areas could potentially occur well after operations have ceased. ■ Due to vitrification of ash during gasification the possible soluble/mobilised contaminants will be sequestered, which will limit their mobility.		expected sequestering of potential contaminants and define source term for possible groundwater contamination. ■ Undertake dedicated numerical groundwater modelling based on the updated source term to quantify expected negligible water quality impact on deep groundwater aquifer.
Possible spread of secondary burning of coal seams after production ceases at a gasifier, causing "expanded" coal depletion with associated potential for groundwater contamination.	Expected rapid cooling of gasifiers after production ceases, oxygen starvation and damping effect of groundwater inflow virtually nullifies any possible reigniting of the coal seam.	No real possibility of occurrence	None
Surface subsidence is likely.	UCG is expected to occur at a depth of 300 m, increasing to 600m. Due to the depth of the UCG, subsidence is unkikely to exceed 1.2 m.	High	None required, expected subsidence too small to affect surface land use adversely

The cost associated with mitigation measures to manage possible latent impacts amount to about R 802 080 as indicated in Table 16-2 below.

Table 16-2: Cost of mitigation of latent environmental impacts

Latent risk identified	Mitigation measures	Cost
Under specific geological conditions underground pockets of contaminated water that have accumulated in UCG cavities could migrate into down-gradient aquifers which have not been subjected to contamination and create a contamination plume	Undertake groundwater monitoring to characterise movement of the groundwater and determine whether a potential contamination plume is forming	R 102 080.00

Latent risk identified	Mitigation measures	Cost
	Undertake numerical groundwater modelling as informed by the groundwater monitoring undertaken during the operational period	R 700 000.00
The possible risk of secondary burning of the coal seam once production has ceased may result in further contamination of the groundwater system	None required – negligible probability	R -
Due to the depth of the UCG operations, only slight localised surface subsidence is expected to occur, but the potential for more significant surface subsidence may exist in areas where the overlying rock layers are faulted.	None required, see Table 16-1 above	R -
Total (Excl. VAT)		**R 802 080.00**

16.3.3 Recommendations

The following recommendations are made to keep closure planning and the associated closure costing for the Africary UCG project up to date and applicable/appropriate to on-site conditions:

- Undertake monitoring and investigations throughout the operational period to inform closure planning and post closure monitoring needs;
- Refine closure measures based on detailed engineering designs and information generated during the operational phase; and
- The closure cost assessment should be updated on an annual basis, taking cognisance of any changes and/or amendments to operational plans or associated infrastructure/facilities, as well as to the identified closure objectives and rehabilitation approach.

17.0 ENVIRONMENTAL AWARENESS PLAN

Africary will establish a procedure for Environmental Awareness Training as part of its Environmental Management System (EMS).

The procedure will include:

- Induction and awareness training for contractors and employees;
- Basic environmental management training;
- Job specific training – training for personnel performing tasks which could cause potentially significant environmental impacts;
- Assessment of extent to which personnel are equipped to manage environmental impacts;
- EMS training;
- Comprehensive training – on emergency response, spill management, etc;
- Specialised skills;

- Training verification and record keeping; and
- Periodic re-assessment of training needs, with specific reference to new developments, newly identified issues and impacts and associated mitigation measures.

Africary will establish a trained and equipped emergency response team to deal with foreseeable incidents such as fires, accidents and environmental impacts.

18.0 UNDERTAKING

The environmental assessment practitioner hereby confirms:

- The correctness, to the best of his knowledge, of the information provided in the specialist reports and of information provided by African Carbon Energy (Pty) Ltd. The information was accepted as being as reliable as information generated during an EIA and a feasibility study, and provided in good faith, can be;
- The inclusion of comments and inputs from stakeholders and I&APs;
- The inclusion of inputs and recommendations from the specialist reports where relevant; and
- The acceptability of the project in relation to the finding of the assessment and level of mitigation proposed.

3 February 2017

19.0 NEXT STEPS IN THE EIA PROCESS

The Final EIA Report and EMP will be submitted to the authorities for decision-making during the first quarter of 2017, together with an updated Comment and Response Report. Stakeholders will be informed of the authorities' decisions and their right to appeal. The soonest expected date for a decision on environmental authorisation by the DMR is towards the middle of 2017.

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GOLDER ASSOCIATES AFRICA (PTY) LTD.

Etienne Roux
Senior Environmental Consultant

Brent Baxter
Project Director

ER/

Reg. No. 2002/007104/07
Directors: SAP Brown, L Greyling, RGM Heath, FR Sutherland

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APPENDIX A

Database of Potentially Interested and Affected Parties

APPENDIX B

Letter of invitation to all stakeholders informing them of the availability of the Final Scoping Report and the date of the Public Meeting

APPENDIX C

The advertisement published in two local newspapers

APPENDIX D

List of Registered I&APs

APPENDIX E

Site Notices

APPENDIX F

Comment and Response Report

May 2017
Report No. 1665716-314466-1

APPENDIX G

South African Water Quality Guidelines

May 2017
Report No. 1665716-314466-1

APPENDIX H

Specialist Studies

APPENDIX I

Document Limitations

DOCUMENT LIMITATIONS

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Africa (Pty) Ltd.
PO Box 6001
Halfway House, 1685
Thandanani Park
Matuka Close
Halfway Gardens
Midrand
South Africa
T: [+27] (11) 254 4800

Golder Associates