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REVISED SCREENING STUDY FOR THE PROPOSED COMBINED CYCLE GAS TURBINE (CCGT) POWER PLANT IN THE AMERSFOORT AREA, MPUMALANGA

A PROJECT FOR ESKOM HOLDINGS LIMITED

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SSI, Environmental Sector

Johannesburg
Building No. 5 | Country Club Estate
21 Woodlands Drive | Woodmead | 2191
PO Box 867 | Gallo Manor | 2052 | Gauteng | South Africa
Telephone | +27 11 798 6001 | Facsimile | +27 11 798 6010
Email | info@bohlweki.co.za | Website www.ssi-dhv.com

Durban
Ground Floor | SSI House | 6 Payne Street | Pinetown | 3610
PO Box 55 | Pinetown | 3600 | KwaZulu-Natal | South Africa
Telephone | +27 31 719 5500 | Facsimile | +27 31 719 5505
Email | info@bohlweki.co.za | Website www.ssi-dhv.com

George
Suite 101 | Bloemfontein Building | 65 York Street | George | 6529
Postnet Suite #200 | Private Bag X6590 | George | 6530 | Western Cape | South Africa
Telephone | +27 44 802 0600 | Facsimile | +27 44 802 0650
Email | info@bohlweki.co.za | Website www.ssi-dhv.com

Pretoria
Fountain Square | 78 Kalkoen Street
Monument Park Ext. 2 | Pretoria | 0181
PO Box 25302 | Monument Park | 0105 | Gauteng | South Africa
Telephone +27 12 367 5800 | Facsimile +27 12 367 5878
Email | info@bohlweki.co.za | Website www.ssi-dhv.com

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Author (s)	Date / location	Signature
Prashika Reddy		

Reviewer
Malcolm Roods

Approval

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1. INTRODUCTION

Eskom Holdings Limited (Eskom) is mandated by the South African Government to ensure the provision of reliable and affordable power to South Africa. Eskom currently generates approximately 95% of the electricity used in South Africa. Electricity cannot be stored in large quantities and must be used as it is generated. Therefore, electricity must be generated in accordance with supply-demand requirements. Eskom's core business is in the generation, transmission (transport), trading and retail of electricity. In terms of the Energy Policy of South Africa "energy is the life-blood of development". Therefore, the reliable provision of electricity by Eskom is critical for industrial development and related employment and sustainable development in South Africa.

1.1. The Need and Justification of the Proposed Project

The Department of Minerals and Energy has established a National Energy Policy and performs Integrated Energy Planning (IEP) to identify future energy demand and supply requirements. The National Energy Regulator of South Africa (NERSA) performs National Integrated Resource Planning (NIRP) to identify the future electricity demand and supply requirements. Similarly, Eskom continually assesses the projected electricity demand and supply through a process called the Integrated Strategic Electricity Plan (ISEP).

Through these assessment and planning processes, the most likely future electricity demand based on long-term Southern African economic scenarios is forecasted, and provides the framework for Eskom and South Africa to investigate a wide range of supply and demand-side technologies and options. Eskom's ISEP provides strategic projections of supply-side and demand-side options to be implemented in order to meet these long-term load forecasts. It provides the framework for Eskom to investigate a wide range of new supply-side and demand-side technologies, with a view to optimising investments and returns.

Based on the above planning processes, and in order to meet the projected 4% annual growth in demand for electricity, various projects are underway and are at various stages of implementation. These include base load technologies such as coal fired plants, combined cycle gas turbines and conventional nuclear as well as peaking technologies such as pumped storage schemes and open cycle gas turbines.

There are a number of projects in Eskom's "project funnel", which demonstrate the range of supply options being considered by Eskom to meet the increasing demand for electricity in the country. These projects are at different stages of development, ranging from research projects to new-build projects.

Eskom is committed to investigating and evaluating various options for the diversification of the energy mix over time (including renewable resources) and as part of an ongoing effort to assess the viability/feasibility of all supply-side options, a number of power generation technologies, not yet implemented in South Africa on a commercial basis, are being evaluated in terms of technical, socio-economic and environmental aspects. One such type of technology is Combined Cycle Gas Turbine (CCGT) Power plant that uses gas from an Underground Coal Gasification (UCG) process as a primary energy, which has been successfully proven to be commercially viable. Eskom plans to use the gas from the UCG facility, which will be implemented as a full commercial operation, as a primary source of fuel for the CCGT power plant to be implemented as a full commercial operation. In this current project, it is proposed that an Underground Coal Gasification-Combined Cycle Gas Turbine (UCG-CCGT) complex is constructed and operated, as explained below.

UCG is a process carried out on coal seams that are not economically viable to mine through conventional mining methods, such as open cast or underground mining. UCG involves injecting steam and air (or oxygen) into a cavity created in an underground coal seam, to form a synthetic burnable natural gas. The burnable natural gas from the UCG plant in the Majuba area will be used as fuel for combined cycle gas turbine (CCGT) technology thus the development of a UCG-CCGT power complex and co-firing with coal in the Majuba power station. The UCG plant on the farm Roodekopjes, Mpumalanga, has proven to be technically feasible for operation beyond the pilot plant level, and its area of operation will expand to identified nearby coal resources in the future.

This study is only applicable to the CCGT component of the complex.

1.2. Overview of the Proposed Project

A CCGT power plant uses a cycle configuration of gas turbines, heat recovery steam generators (HRSGs) and steam turbines to generate electricity (see Figure 1.1 below). A combined cycle is characteristic of a power producing engine or plant that employs more than one thermodynamic cycle. Heat engines are only able to use a portion of the energy their fuel generates (usually less than 50%), with the remaining heat from combustion generally being wasted. The combination of two or more "cycles" such as the Brayton Cycle and Rankine Cycle results in improved overall efficiency as no/less heat is wasted.

In a CCGT power plant, a gas turbine generator generates electricity and the ‘waste’ heat is utilised to produce steam to generate additional electricity *via* a steam turbine cycle; this last step enhances the efficiency of overall electricity generation. In a thermal power plant, high-temperature heat as input to the power plant, usually from burning of fuel, is converted to electricity as one of the outputs and low-temperature heat as another output. As a rule, in order to achieve high efficiency, the temperature difference between the input and output heat levels should be as high as possible . This is achieved by combining the Rankine (steam) and Brayton thermodynamic cycles.

The CCGT plant has a boiler called a Heat Recovery Steam Generator (HRSG) which produces steam using the exhaust gas at approximately 600 °C from an open cycle gas turbine. The steam is then used to drive the steam turbine which is also linked to the generator.

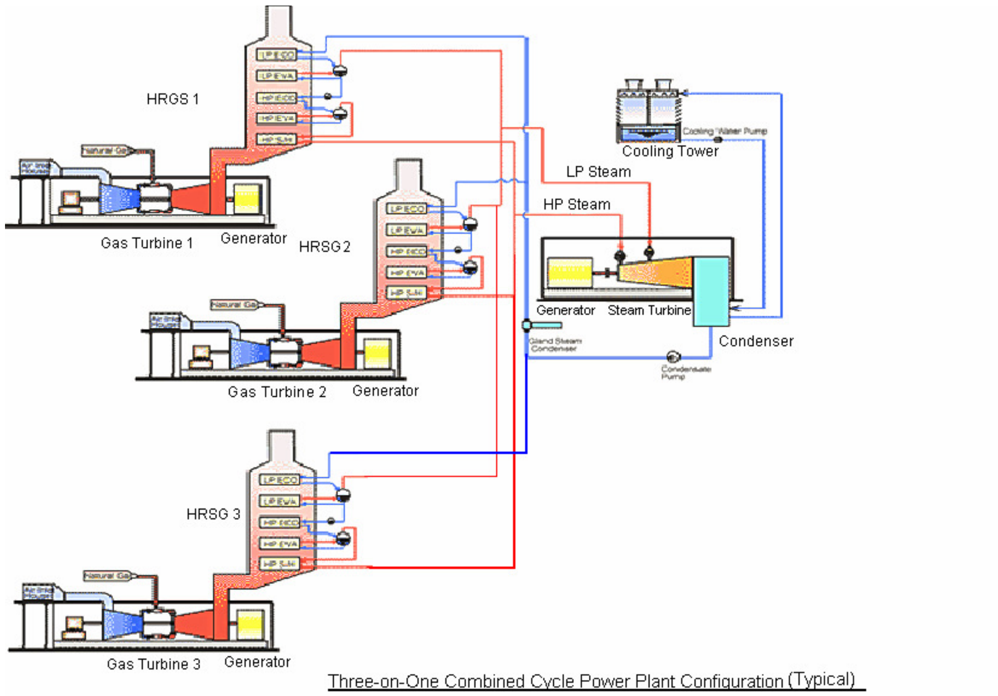

Figure 1.1 A typical 3-in-1 CCGT power plant configuration, in model form

1.2.1. How does a Combined Cycle Gas Turbine (CCGT) work?

The gas turbine (also called a combustion turbine or just the turbine element) is a rotary engine that extracts energy from a flow of combustion gas and is the first stage in the process of producing electricity through a CCGT plant. It has an upstream compressor coupled to a downstream turbine, and a combustion chamber in-between. Figure 1.2 is the schematic of a gas turbine used for the electrical power production. A typical gas turbine unit consists of three major parts:

- **Compressor** – which compresses the incoming air to high pressure;
- **Combustion area** – which burns the fuel and produces high-pressure, high-velocity gas; and
- **Turbine** – which extracts the energy from the high-pressure, high-velocity gas flowing from the combustion chamber

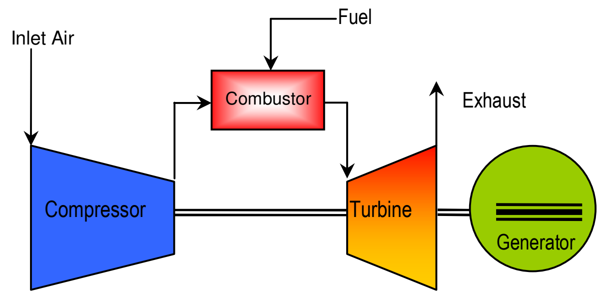

Figure 1.2 Schematic of a process of that a gas turbine undergoes in order to produce electricity.

The gas turbine compressor draws in air from the environment *via* a filter. This air is compressed in the compressor, thus being elevated to a higher pressure, and then directed into the combustion chamber. This combustible gas is then mixed in and combustion takes place generating hot gases under high pressure. The energy released is converted into a mechanical rotation which powers the compressor and the generator.

When used for power production, gas turbines can either be operated in an open cycle mode (exhaust to atmosphere) often referred to as an Open Cycle Gas Turbine (OCGT), or in a combined-cycle mode (CCGT – Combined Cycle Gas Turbine). A key feature of the thermodynamics of the gas turbine cycle is that the temperature of the turbine exhaust stream is typically in the range of 500℃ – 600℃. This heat energy is transferred to the water in the heat recovery steam generator. The heat is used to generate water vapour, which powers the steam turbine. The resulting mechanical energy is transferred to the generator. In the generator, mechanical energy from the steam turbine is converted into electricity. The condenser converts exhaust steam from the steam turbine back into water by means of cooling.

It is anticipated that the CCGT power plant will have approximately 2100 MW of installed capacity. The proposed project will consist of the following components:

- the CCGT power plant (comprising up to 6 units of approximately 350 MW each);
- a compressor plant;
- ignition gas plant, for unit start-up (using commercial propane);
- weather and communication mast of up to 60 meters in height and air quality monitoring station;
- high voltage yard;
- a gas pipeline from the adjacent gas cleaning plant to the CCGT;
- a water supply pipeline from the Majuba allocation or the Rietpoort Balancing Dam (for construction and operational water supply);

- electricity supply for construction;
- a water treatment plant as well as ancillary works such as other associated infrastructure;
- access roads (temporary and permanent);
- sewage treatment plant;
- storage facility for hazardous materials including cement, batching plants etc.;
- storage facility for waste (temporary and permanent storage of general and hazardous waste);
- construction village; and
- borrow pits.

2. APPROACH TO SITE SELECTION

2.1. Introduction

A site-selection process was initiated in the pre-screening study to identify feasible sites within the study area. The study area was demarcated using a 10 km radius around the UCG plant, off coal resources. A sensitivity mapping exercise was undertaken for the study area in order to establish the best possible sites to evaluate during the Scoping phase of the project. The purpose of such an exercise was to identify suitable areas within the study area that could accommodate the CCGT plant and associated infrastructure and to pro-actively identify sensitive areas that should be avoided.

2.2. Sensitivity Mapping

The qualitative sensitivity mapping exercise divided the study area into three categories *viz.* ideal, acceptable and sensitive. A site sensitivity map for the study area, indicating sensitive areas, acceptable areas (areas with medium or average sensitivity) and ideal areas (least sensitive areas), was requested from each of the following specialist fields:

Biophysical

- Groundwater
- Surface Water
- Ecology

Social

- Air
- Noise
- Social
- Heritage
- Visual
- Risk
- Traffic

The social specialist did not provide a map as their sensitivity map was largely informed by the presence of farmhouses and the visual sensitivity map. Furthermore, no sensitivity maps were received from the heritage and traffic specialist fields as it was indicated that the entire study was acceptable for the development of the CCGT power plant.

Table 2.1 provides a description of the various categories used in the sensitivity mapping.

Table 2.1 Description of the various categories used in the sensitivity mapping

Study Component	Category	Description
Hydrogeology	Sensitive	Shallow coal, average borehole yields > 0.8 l/s, average groundwater levels < 10 m.
	Acceptable	Deep coal, average borehole yields 0.3 to 0.8 l/s, average groundwater levels 10 -20 m.
	Ideal	Average borehole yields <0.3 l/s, average groundwater levels > 20 m.
Hydrology	Sensitive	Within 100 m of water bodies and on slopes steeper than 5%.
	Acceptable	Over 100 m from water bodies and on slopes of less than 5%.
	Ideal	Over 200 m from water bodies on slopes of less than 2%.
Ecology	Sensitive	Wetlands, rivers, streams, marshes, rocky outcrops, pristine grassland, Red Data habitat.
	Acceptable	Agricultural lands, degraded grassland.
	Ideal	Transformed habitat, areas of extensive degradation, existing infrastructure.
Air Quality	Sensitive	Zone containing potentially expanding and permanent residential settlements that would be affected by the proposed development.
	Acceptable	Zone within wind dispersion field with potentially sensitive receptors but whose land if purchased by Eskom would be relocated and would no longer be considered sensitive.
	Ideal	Zone within wind dispersion field and with no potentially sensitive receptors.
Noise	Sensitive	Zone 3: • The new facility should be closer than 4 km to urban areas (the town of Amersfoort) and any informal settlement. • Areas east of National Road N11.

Study Component	Category	Description
	Less acceptable	Zone 2: Areas where construction is possible, as the Majuba power station is already the centre of a noise degraded area, but less desirable than in Zone 1.
	Most acceptable	Zone 1: Area at or within a 10 km radius of the Majuba Power Station. Subject to consideration of isolated noise sensitive sites. Proviso that if the CCGT power plant is at or within three (3) kilometers of the Majuba Power Station, special consideration is to be given to the acceptability of the cumulative affects at affected noise sensitive sites.
Social **a. Demographic**	Sensitive	Displacement and resettlement of people are necessary. Inhabitants of houses in close proximity to the proposed CCGT do not have the choice to resettle elsewhere (distance informed by visual, noise and risk specialist study).
	Acceptable	Visual, noise, air quality and traffic impacts on affected parties are highly significant during construction, but acceptable during operation (to be informed by the relevant specialists).
	Ideal	No displacement and resettlement of people are necessary. Houses are not in close proximity to the proposed CCGT (distance informed by visual, noise and risk specialist study).
b. Economic and Land Use	Sensitive	Land use is affected in such a way that those who are dependent on the land to make a living are affected, and mitigation measures cannot neutralise the impacts. Good agricultural land is lost. Potential mining land is lost.
	Acceptable	Land use is affected in such a way that those who are dependent on the land to make a living are affected, but mitigation measures can neutralise the impacts. Land that was mined and which are stable, not potentially putting people's safety at risk.

Study Component	Category	Description
	Ideal	Land use activities can carry on, and people who are dependent on the land to make a living can carry on with their activities. Good agricultural land is not affected. Potential mining land is not affected.
c. Socio-cultural	Sensitive	Socio-cultural activities cannot carry on, and sense of place is irrevocably changed.
	Acceptable	Socio-cultural activities and sense of place are affected but can be mitigated.
	Ideal	Socio-cultural activities are not affected and the sense of place is not disturbed.
d. Institutional	Sensitive	New services and infrastructure is necessary, and not clustered in the vicinity of similar activities.
	Acceptable	Although new services and infrastructure will be necessary, the proposed project is placed in the vicinity of similar activities.
	Ideal	As far as possible, link up with existing services and infrastructure.
Heritage	Sensitive	Heritage resources with qualities so exceptional that they are of special national significance.
	Acceptable	Heritage resources which, although forming part of the national state, can be considered to have special qualities which make them significant within the context of a province or a region.

Study Component	Category	Description
	Ideal	Other heritage resources worthy of conservation, and which prescribes heritage resources assessment criteria, consistent with the criteria set out in section 3(3) of the National Heritage Resources Act (Act No 25 of 1999), which must be used by a heritage resources authority or a local authority to assess the intrinsic, comparative and contextual significance of a heritage resource and the relative benefits and costs of its protection, so that the appropriate level of grading of the resource and the consequent responsibility for its management may be allocated in terms of section 8 of the said Act.
Visual	Sensitive	Areas within a 2 km buffer from populated places (Amersfoort, Vlakplaats and Daggakraal). Areas within a 500 m buffer zone of major roads. Areas that fall within elevated topographical units (e.g. ridges, crests, hills, etc.).
	Acceptable	Areas not falling within the *Ideal* or the *Sensitive* categories.
	Ideal	Areas within a 2 km buffer zone from already vertically disturbed industrial or mining land.
Risk **a. Toxics**	Sensitive	Not applicable
	Acceptable	Not applicable
	Ideal	1 % fatality
b. Flash Fires	Sensitive	½ Lower Flammable Limit
	Acceptable	Not applicable
	Ideal	Not applicable

3. GENERAL DESCRIPTION OF THE STUDY AREA

3.1. The Biophysical Environment

3.1.1. Geology

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

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

Four generations of dolerite intrusions are recognised within the study area, based on olivine or plagioclase content, alteration, and texture. The intrusive dolerite has produced large-scale devolatilisation and structural displacement of the coal. These adverse geological conditions caused the closure of the Majuba Colliery in 1993.

Table 3.1 presents the lithostratigraphy of the study area.

Table 3.1 Lithostratigraphy of the study area

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

3.1.2. Hydrogeology

The groundwater potential of the Karoo formations located in the study area is limited in their pristine state due to low permeability and storage capacity. Secondary processes, such as weathering, fracturing, etc., are required to enhance the groundwater potential.

Based on regional data, the hydrogeological resource maps, the following hydrogeological information is available for the formations within the study area: -

Volksrust Formation - Upper and middle Ecca

	-	Predominantly argillaceous rocks
	-	Fractured aquifers
	-	Borehole yields 0.5 to 2.0 l/s
Vryheid Formation	-	Lower Ecca
	-	Intergranular and fractured aquifers
	-	Borehole yields 0.1 to 0.5 l/s

Groundwater hydrochemistry associated with the sediments is variable; the groundwater salinity associated with the formations in the study area can have electrical conductivity concentrations of < 250 up to 1000 mS/m.

The sandstones of the Vryheid Formation of the Ecca Group can be massive and dense and have limited permeability and storage. It thus offers only moderate groundwater yield, especially in the absence of dolerite intrusions.

Contacts between different rock lithologies and bedding planes within the sediments often yield groundwater. The contact zone between the dolerites and the sandstone lithologies can be high yielding. Fractured fault zones, especially if related to tensional stresses, are potentially rich targets for groundwater development.

Groundwater occurs within the joints, bedding planes, and along dolerite contacts within the sediments (as recognised across the study area).

3.1.3. Hydrology

The region in which the CCGT will be situated has a slope varying between from below 1 to above 100% and contains a number of streams and rivers. Most of these are small drainage lines that flow only periodically but a few are perennial rivers with a constant overview. The steeper slopes and the areas around the rivers are the most sensitive areas from a surface water point of view and hence a large area within the 12 km zone around the pilot UCG plant is sensitive from a hydrological point of view.

3.1.4. Biodiversity

The study area is situated in the Amersfoort Highveld Clay Grassland (Mucina and Rutherford, 2006). This vegetation type comprises undulating grassland plains, with small scattered patches of dolerite outcrops in areas. The vegetation is comprised of short closed grassland cover, largely dominated by a dense *Themeda triandra* sward, often severely grazed to form a short lawn.

The conservation status of the study area is regarded as Vulnerable, with a target of 27%. The vulnerable status that is attributed to the vegetation of the area is determined by the

VEGMAP database and is based on various targets as well as the regional status of this vegetation type. It must also be borne in mind that the Vulnerable status will, therefore, only be applicable to natural grasslands of the study area, not the entire study area.

Some 25% of this unit is transformed, predominantly by cultivation (22%). The area is not suited to afforestation. Silver and black wattle and *Salix babylonica* invade drainage areas and the erosion potential is low.

Overgrazing leads to invasion of *Stoebe vulgaris*. Parts of this unit were once cultivated and now lie fallow and have been left to re-vegetate with pioneer grass species. These transformed areas are not picked up by satellite for transformation coverage and the percentage of grasslands still in a natural state may be underestimated.

3.2. The Social Environment

3.2.1. Air Quality

During the screening phase of the project, hourly meteorological data sourced from the UCG Pilot Plant Weather Station was used to determine the atmospheric dispersion potential of the area. The data set spanned the period from October 2006 to August of 2007. Figure 3.1 depicts the wind rose and wind class frequency distribution graphs that were extracted from the data provided. The dispersion potential of the area is briefly described by the wind rose and wind class frequency distribution graph presented in Figure 3.1. The Majuba UCG pilot plant is associated mostly with winds originating from a westerly and easterly direction as is depicted by the wind rose. The field flowing from the west is characterised by high wind speeds greater than 8 m/s, which suggests that pollution emanating from the proposed facility, could be dispersed for large distances eastward from the site. Winds from the east are also noted to occur for 33% of the time, which have a potential to distribute pollutants from the proposed facility in a westerly direction. Calm winds (winds less than 0.5 m/s) are noted to occur 0.6% of the time. Consequently the resultant flow field is from west to east.

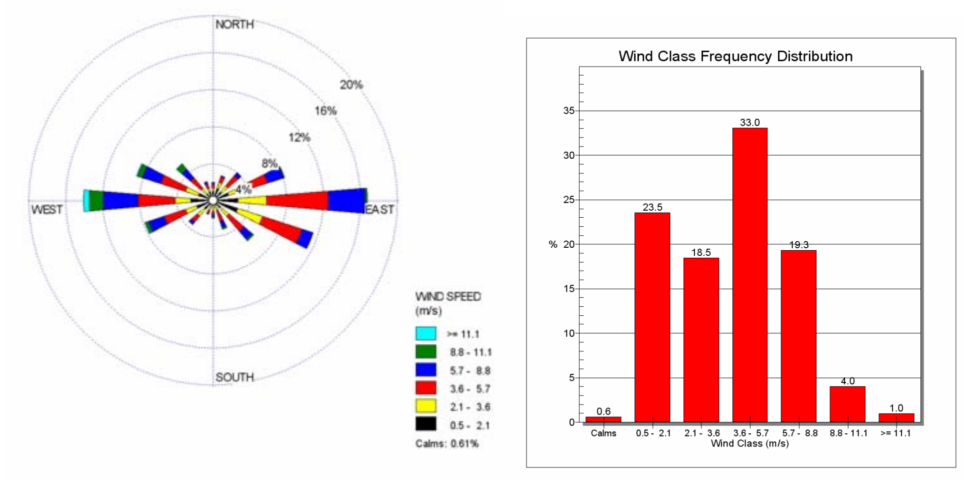

Figure 3.1 The period wind rose and wind frequency distribution for data taken at the Majuba UCG Pilot Plant.

The air quality study criteria used to undertake the sensitivity analysis are summarised as the proximity of the sensitive receptors in the area to other industrial operations in the area and the dispersion potential of the pollutants released into the study area.

The sensitive receptors can be defined as the farms and dwellings that are situated adjacent to (eastward of) the existing Majuba power station. The Amersfoort Town is also situated to the north of the Majuba power station.

The already existing Majuba power station is a potential source of emissions that is contributing to the background pollution levels in the area. This will need to be assessed along with the proposed operations to evaluate cumulative impacts. This will be done in the EIA phase.

3.2.2. Noise

The *noise climate* (ambient noise condition) in the Amersfoort area is quiet and is representative of a rural (farming) noise district (SANS 10103). There is, therefore, a potential for noise impact with the introduction of a new facility such as the CCGT power plant. There are a number of major noise sources in the area namely the existing Majuba power station, the traffic on the main roads and the coal supply railway line to the power station. The noise sensitive sites/areas are Amersfoort town and various farm houses and farm labourer residences in the surrounding area.

3.2.3. Social

The proposed project falls in the Mpumalanga Province in Ward 7 of the Pixley ka Seme Local Municipality (MP 304) within the Gert Sibande District Municipality (DC30).

The Pixley ka Seme Local Municipality lies on the eastern border between Mpumalanga and KwaZulu-Natal. A total of 80 737 people reside within the area in 16 726 households (average 4.8 people per household). Of these residents, 68% of the people live in urban areas, with the remaining 32% residing in largely rural areas. In 2001, just over half (51%) of the people were unemployed, which differs significantly with the unemployment rate of 1996 where it was estimated that only 33% of the population were unemployed. Of those employed, the majority (24%) are employed in the agriculture/forestry and fishing economic sector. This is closely followed by those employed in private households (20%).

According to the IDP of the Pixley ka Seme Local Municipality (2000 Demarcation Data and 2001 Census Data), the ward is characterised by:

- About 5% of the Local Municipality's population falls in this ward;
- One (1) in Five (5) inhabitants is Indian;
- The majority of the population falls within the 15-64 year old age bracket;
- Approximately three quarters of the population do not have a personal income;

- Approximately $^{2}/_{3}$ of households have water inside their yards;
- About 75% of the population in the ward has flush toilets;
- 80% of the population have electricity for lighting; and
- The water demand exceeds capacity.

3.2.4. Heritage

- Stone Age

No information about Stone Age habitation of the area is available. There might be two reasons for this. Firstly, it is unlikely that Stone Age people would have occupied the area, as it would have been too cold and no shelters or caves are known to exist in the area. Secondly, no systematic survey of the area has been done and, as a result, no sites have been reported. However, it is quite likely that a detailed survey would reveal traces of these early people's occupation of the area.

- Iron Age

Iron Age people started to settle in southern Africa c. AD 300, with one of the oldest known sites at Silver Leaves, south east of Tzaneen dating to AD 270. However, Iron Age occupation of the eastern highveld area (including the study area) did not start much before the 1500s. Occupation of these areas became possible due to wide-scale climatic changes, as well as the introduction, from the east coast, of cereal crops such as mealies. Some sites dating to the Late Iron Age are know to exist to the north-west of the study area, as well as approximately 15 km due south. These are typically stone walled sites. They were occupied by a number of related people, varying in size from twenty to as many as a few hundred individuals. The people cultivated various crops and kept large herds of cattle.

- Historic period

The historical period in this area started with the arrival of early explorers, hunters and traders, followed later by the Voortrekkers, who settled permanently and started to farm in the area and developed a number of towns. During the Anglo Boer War (1899-1902), some skirmishes took place in the region.

Apart form urban areas, such as Amersfoort, which have origin dates to the late 1880s, most heritage resources in this part of the world would be related to farming and infra-structural development. Most farmsteads were burned down by the British during the Anglo-Boer War, but were later rebuilt. Typically, these consist of the main house, outbuildings, stock enclosures and cemeteries. The housing of labourers were much more informal and once abandoned, quickly disintegrated.

3.2.5. Risk

The main hazards of the project would be exposure to toxic fumes of carbon monoxide and the thermal radiation of the fuel containing carbon monoxide and hydrogen. Carbon monoxide is an odourless and colourless gas having the same density of air. It is extremely flammable and mixes well with air easily forming an explosion hazard. When burnt, carbon monoxide produces carbon dioxide a less toxic material that is considered a simple asphyxiant.
In the presence of finely dispersed metal powders the substance forms toxic and flammable carbonyls. Carbon monoxide may react vigorously with oxygen, acetylene, chlorine, fluorine, nitrous oxide. In the presence of finely dispersed metal powders the substance forms toxic and flammable carbonyls. Carbon monoxide is absorbed into the body by inhalation and acts a chemical asphyxiant by combining with the haemoglobin in the blood displacing the oxygen. Short-term exposure may cause effects on the blood, cardiovascular system and central nervous system. Exposure to concentrations of over 1.3% may result in lowering of consciousness and death. Long-term exposure may have effects on the nervous system and the cardiovascular system, resulting in neurological and cardiac disorders.

Hydrogen is a colourless, odourless gas that is flammable over a wide range of vapour/air concentrations. Hydrogen vapour forms an explosive mixture with air. Vapours or gases may travel considerable distances to ignition source and flash back. Leaking hydrogen may ignite in the absence of any normally apparent source of ignition and if so, burns with a practically invisible flame that can instantly injure anyone coming in contact with it. Hydrogen gas is very light and rises rapidly in the air; concentrations may collect in the upper portions of buildings. Liquid hydrogen can solidify air and may create an explosion hazard.

3.2.6. Visual

The study area for the placement of the CCGT is located in the Amersfoort region of the Mpumalanga province and encompasses the town of Amersfoort, the Majuba coal fired power station and two other predominantly agricultural settlements, namely Vlakplaats and Daggakraal.

The study area has a rural character with dry-land agriculture and cattle and game farming as primary economic activities. It is situated within the grassland biome and the terrain morphological description is strongly undulating plains and hills and lowlands with mountains towards the south-west of the study area. The population density is roughly 30 people per square kilometer, and is primarily concentrated within the town of Amersfoort and the other two main settlements.

The N11 national road and the R23 arterial road affords access to the study area. Standerton and Volksrust are the two major towns in closest proximity to Amersfoort

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4. SENSITIVITY ANALYSIS

4.1 Biophysical Impacts

4.1.1 Hydrogeology

Figure 4.1 shows the areas that are ideal, acceptable, and sensitive from a preliminary hydrogeological perspective. The data conveyed in the figure must be considered preliminary and based on average data and regional information rather than site specific data. It does, however, highlight areas which could be considered more favourable from a hydrogeological point of view.

Areas shown as red in Figure 4.1 should be considered sensitive and of least suitability for development. The red areas to the north have shallow groundwater levels, which are recognised as more vulnerable to potential surface contamination sources. This is due to the limited barrier potential of the unsaturated (vadose[1]) zone, where attenuation of poor quality seep / infiltration can occur.

The available hydrogeological data indicates that groundwater levels to the north of study area are shallow and are thus envisaged to be more vulnerable to potential contamination. The central portion of the study area is underlain by Vryheid Formation geology and thus is recognised to have lower groundwater potential and deep groundwater levels. The southern portion of the study area is underlain by Volksrust Formation rocks, which have greater groundwater potential (when compared to the Vryheid Formation sediments) and moderate groundwater levels.

The central portion of the study area (as envisaged in Figure 4.1, a 3 km radius around the existing Majuba Power Station) including the Farm Roodekopjes, is therefore recognised to be more favourable for the CCGT plant, due to deeper groundwater levels and lower groundwater potential within the Vryheid Formation geology from a hydrogeological perspective.

The yellow zone to the south is recognised as acceptable as the average groundwater levels are between 8 and 15 m below surface but the groundwater potential (average yields 0.5 to 2 l/s) is enhanced within the Volksrust Formation.

The resultant figure (Figure 4.1) reflects the general hydrogeology across the study area, indicating vulnerable more sensitive areas to the north, ideal areas in the center, and acceptable areas to the south. Farms where site specific data was obtained are indicated on the map, thus providing variations to the general trend across the study area. Farms Mezig and Bergvliet have groundwater records which indicate shallow groundwater conditions, thus making these farms more sensitive. It must be noted that this approach assumes the entire

[1] The portion of Earth between the land surface and zone of saturation. It extends from the top of the ground surface to the water table.

farm to be underlain by shallow groundwater, when in reality areas of these farms may still be suitable for the proposed CCGT plant.

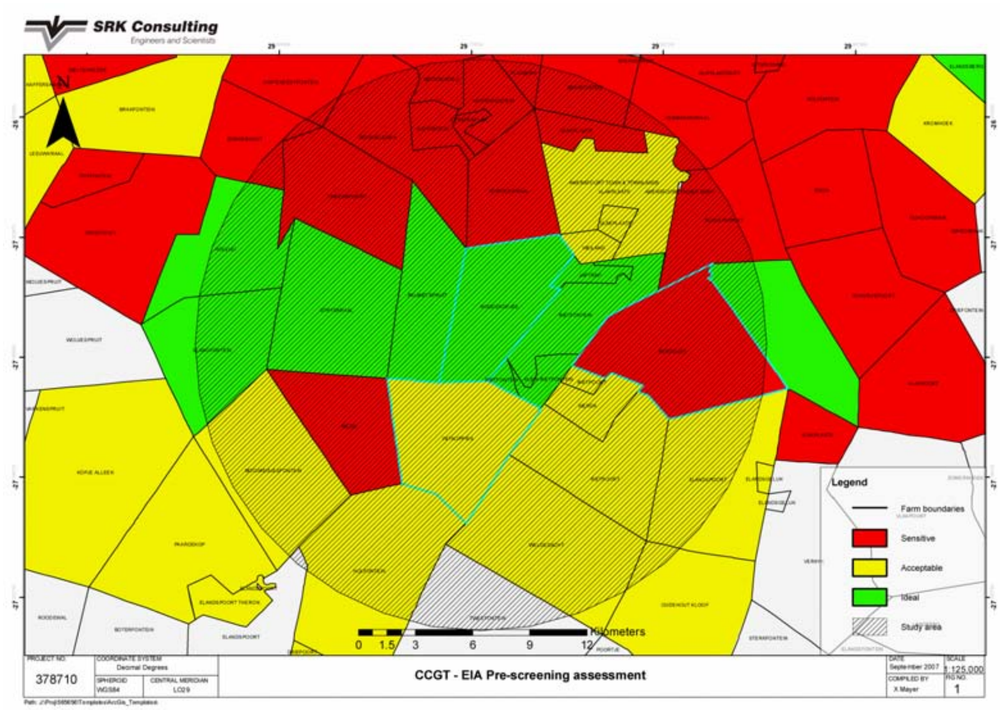

Figure 4.1 Sensitivity map showing areas that are ideal, acceptable and sensitive in terms of hydrogeological impacts.

4.1.2 Hydrology

Figure 4.2 shows the areas that are ideal, acceptable and sensitive from a hydrological point of view. Areas shown as red should be considered sensitive and of least suitability for development. In many cases these areas will require river diversions and water use license applications to DWAF as they likely to be in the floodline. Where the sensitive areas are not near a river they are due to steep slopes that will make stormwater control difficult.

Areas shown as yellow are acceptable but not ideal and from a hydrological point can be developed. Areas shown as green are the most ideal and these areas can be developed with little impact on surface water.

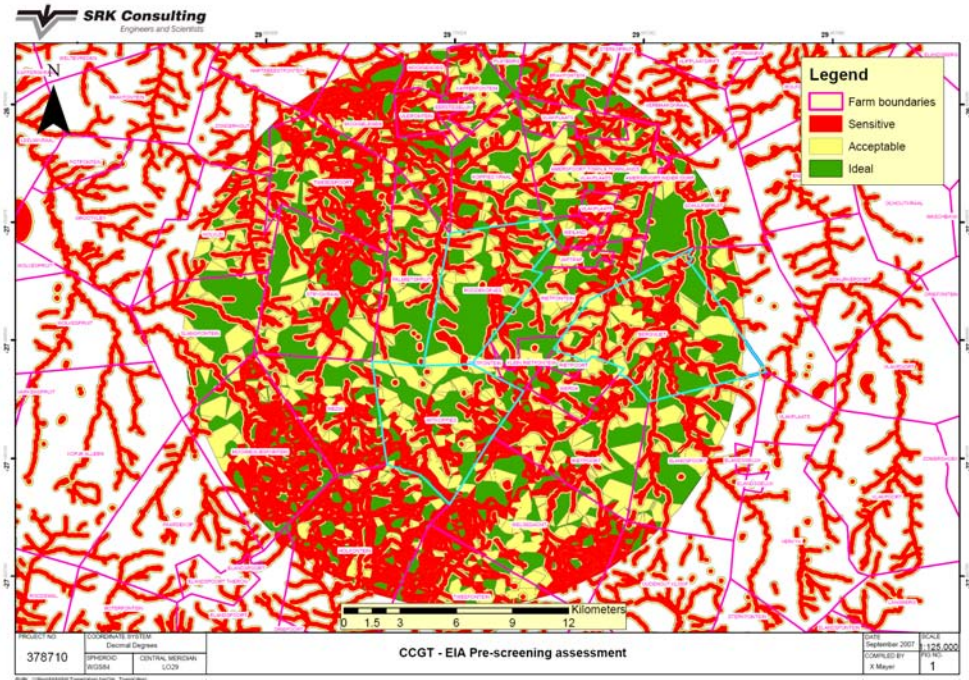

Figure 4.2 Sensitivity map showing areas that are ideal, acceptable and sensitive in terms of hydrological impacts.

4.1.3 Biodiversity

Grassland areas constitute important and sensitive ecological habitats, providing important refuge areas for a high diversity of animals, some of which may be endemic or regionally sensitive. The status of grasslands in the region presents the main problem of this particular assessment as available aerial photography does not accurately reflect the status of grassland regions. This aspect will enjoy particular attention in the Scoping and EIA phases of this particular project. For the moment it was accepted that all areas that could be identified as grassland, are pristine.

The identification of wetlands, rivers, streams and marshes also proved problematic at this stage. Available information will be sourced and the level of detail will be updated.

It is recommended, with a relative high degree of certainty that all areas that constitute wetland or pristine grassland habitat is regarded sensitive and should ideally be excluded from the proposed development.

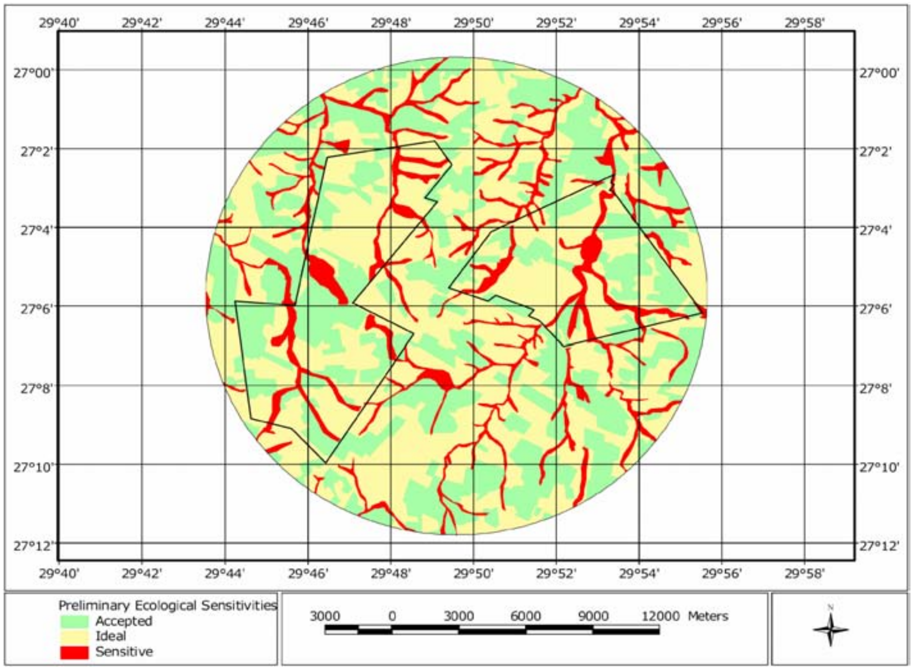

Figure 4.3 Sensitivity map showing areas that are ideal, acceptable and sensitive in terms of biodiversity impacts.

4.2 Social Impacts

4.2.1 Air Quality

The wind field is predominantly west to east although there are periods of significant east to west movements as well. Taking the perimeter of the existing Majuba power station as the point of reference, the sensitive receptors span the eastern to northern segment around the existing power station. There are no sensitive receptors that are apparent around the southern segment of the Majuba power station. The EIA phase will further evaluate the impacts of the aforementioned phenomenon during the modeling exercise to be conducted. This will evaluate amongs other things the effect source characteristics and dispersion potential on pollution movements.

Based on the preliminary assessment results, three bands of varying sensitivity have been identified. These are the ideal blue zone to the south of the Majuba power station, the yellow zone in the center and the red zone to the north of the Majuba power station (Figure 4.4). This assessment has been based primarily on the presence of sensitive receptors and the dominant wind field in the area and has not taken into account the type of emissions which would be released from the proposed CCGT power plant and associated infrastructure. At this stage of the investigation not enough is known about the potential emissions which could be released during the process to be included into this assessment.

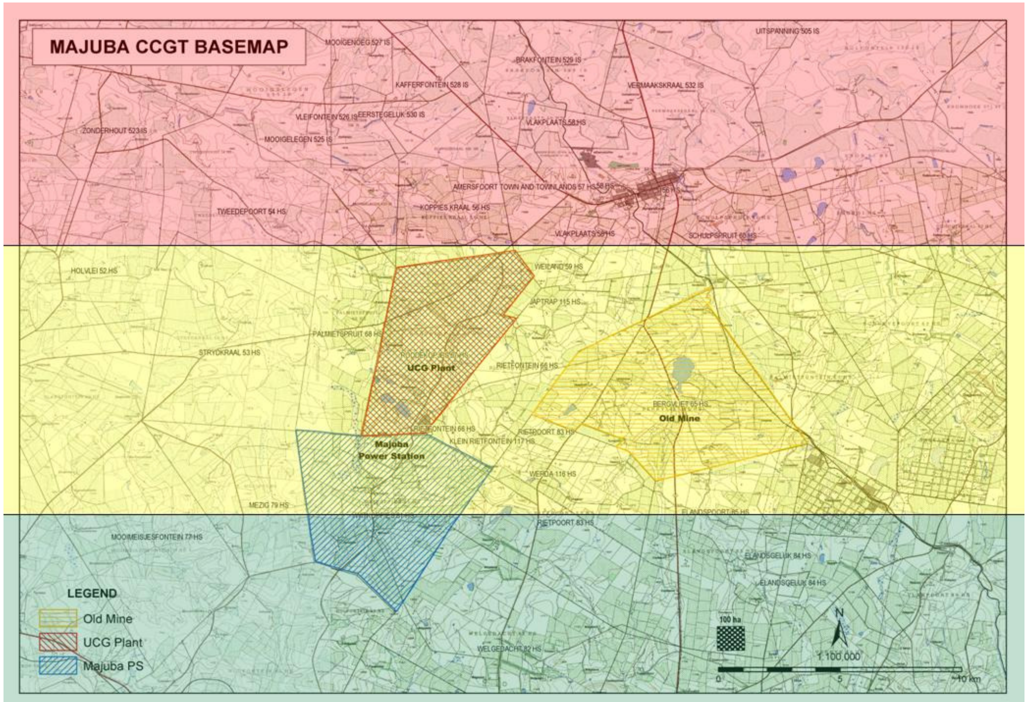

Figure 4.4 Sensitivity map showing areas that are ideal (green), acceptable (yellow) and sensitive (red) in terms of air quality impacts.

4.2.2 Noise

The area within a 10 km radius of the Majuba Power Station was analysed in detail. There were also several sectors where there were noise sensitive sites just outside the 10 km limit that could potentially be impacted, and in these cases a 12 km radius was used. National Road N11 was used as an expansion limit in the east, and sections of the Perdekop Road as a desirable expansion limit in the north-west.

The noise sensitive sites/areas are Amersfoort Town and various farm houses and farm labourer residences in the surrounding area. These are relative evenly spread out throughout the area. An analysis of the area within a 10 - 12 km radius of the Majuba Power Station (but maintaining the National Road N11 as an eastern limit) indicated that there was approximately the following number of noise sensitive sites (farmhouse and farm labourer homes) in the given quadrants of the 12 km circle:

Quadrant	No. of Noise Sensitive Sites
North-west	20
North-east	10
South-east	19
South-west	23

It should be noted that there are topographical restraints approximately 7.5 km to the south and south-west of the power station. Although the new facility cannot be built in these areas, some of the noise sensitive sites are located in this far-distance sector and could still be impacted by noise from the new facility.

Figure 4.5 indicates the zones (I, II and III) that are acceptable (ideal), less acceptable (acceptable) and sensitive for the construction of the CCGT and associated infrastructure. The characteristic of each zone is described below, where

Zone 1 (Green): This zone is continuous and incorporates the area at the Majuba power station, the area north of the power station up to the Perdekop Road, the area between the existing power station, the UCG facility and the old mine (north-eastern quadrant), the area to the south-east of the power station (inner portion of the south eastern quadrant), and small areas to the south-west and west of the power station. The existing power station is already a source of noise. Locating the new facility at or too close to the existing power station will have cumulative effects, but because it is the centre of an existing noise degraded area, there are advantages to locating the new facility reasonably close to Majuba Power Station. If the CCGT plant is located at or within 3 km of Majuba Power Station (see circle around the power station), special consideration will need to be given to the acceptability of the cumulative effects at affected noise sensitive sites.

Zone 2 (Yellow): The CCGT plant can be introduced to almost any new area, but it is desirable not to move a new major noise source into areas too far away from the existing power station as this has the potential to introduce new impact situations. These zones are generally outside Zone 1. Four areas have been categorised as Zone 2 areas, namely one to the north, two to the south-east and one to the west of the existing power station.

Zone 3 (Red): The main no-go areas are those in close proximity to urban areas and informal settlements. In order to limit the night time noise impact on the Amersfoort Town, the new facility should not be closer than 4 km to the town (SANS 10103 night time standard for urban areas). Areas east of National Road N11 should be avoided, particularly areas that get close to Vlakplaats and Daggakraal.

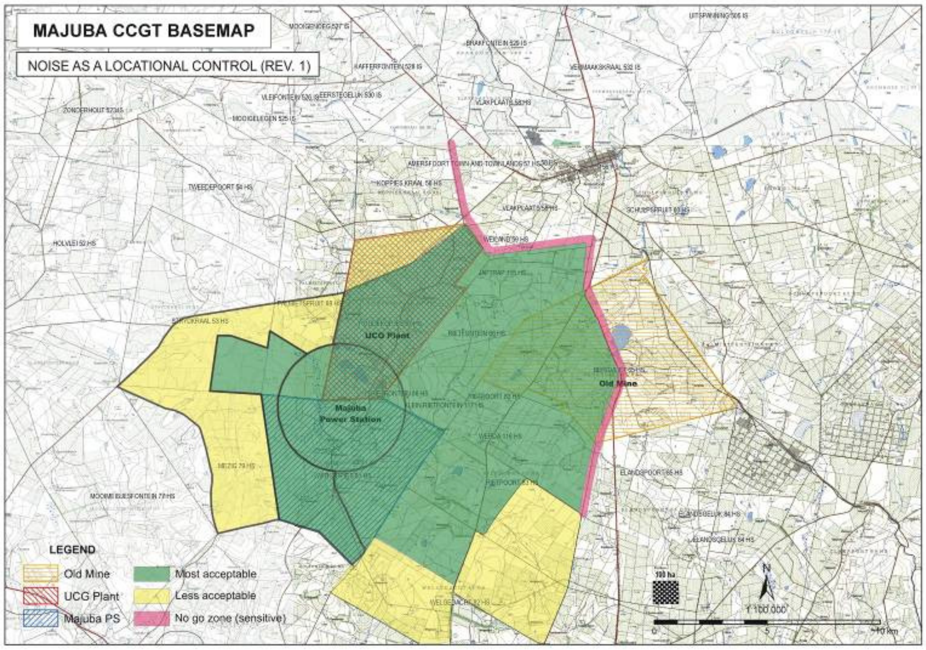

Figure 4.5 Sensitivity map showing areas that are acceptable, less acceptable and sensitive in terms of noise impacts.

4.2.3 Social

- *Demographic Processes*

The study area is sparsely populated. The closest town is Amersfoort on the northern border of the study area. The informal settlement to the west of the town, north of the N11, is growing. It does not appear as if formal structures in the town are on the increase. Isolated farm houses occur in the study area, and these are depicted on the sensitivity map. The total number of farm houses observed in the study area was approximately eight (8) and four (4) clusters of traditional huts / workers' huts were observed. There are on average 4-5 houses/huts in these clusters.

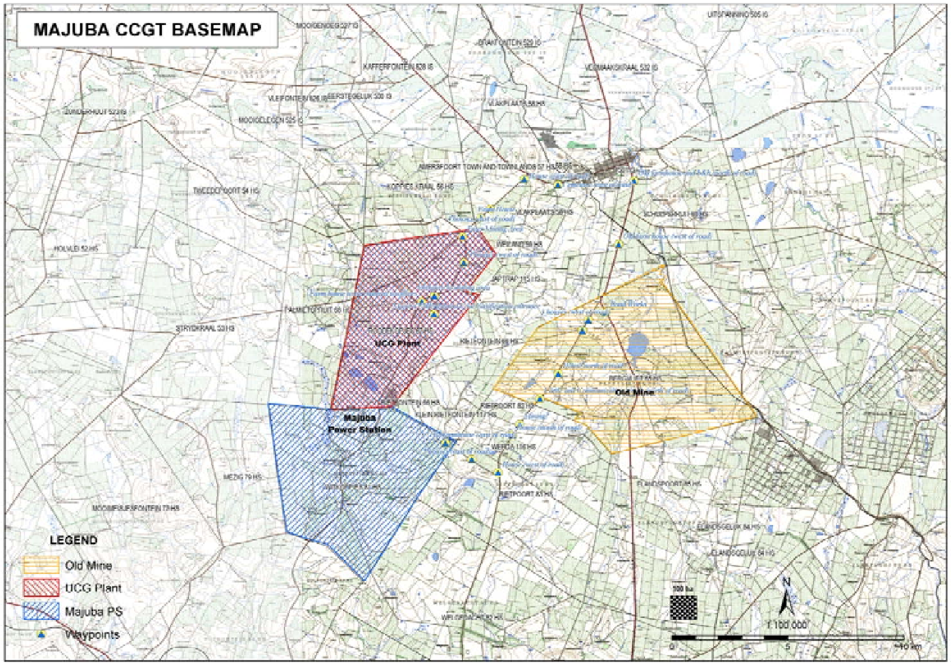

Figure 4.6 Map indicating the location of farmhouses in the study area.

- ***Economic and Land Use Processes***

The UCG pilot plant, Majuba power station and an old mine are located in the study area. Farming activities consist of the grazing of cattle and cultivation of mealies. The Department of Land Affairs plans to purchase grazing land in the area. The IDP lists the Majuba Mining Complex as an opportunity for growth, as well as the availability of agricultural land. This gives an indication that the agricultural activities are important for the economic development of the area.

- ***Socio-Cultural Processes***

There are plans to develop the Amersfoort Dam to the north of the study area into a recreational area. A private developer has plans to develop an exclusive residential development for city dwellers to the north of Amersfoort. At this stage, more information on planned tourism and residential development in the area is not available. Not enough information about the cultural landscape is available at this stage, as this will have to be informed by the affected parties. Therefore at this stage, the results of the Visual Assessment are considered sufficient to address potentially sensitive areas.

- ***Institutional Processes***

The local municipality will have to extend existing infrastructure (water and electricity) to service the CCGT. If construction workers and permanent workers are housed on site, this may necessitate the development of infrastructure for the provision of services. The municipality already lacks capacity and finance to provide services to its current inhabitants.

The sensitivity map for social impacts is largely informed by the visual sensitivity map (see Section 4.2.6, Figure 4.7) for this screening exercise. The visual sensitivity map can therefore be used as a reference.

4.2.4 Heritage

Without a detailed survey, it is difficult to describe specific issues with regard to sensitivity. However, based on experience, some generalised sensitivities can be identified:

- In the past, people used to settle near water sources. Therefore, riverbanks, rims of pans and smaller watercourses should be avoided as far as possible.
- In this particular part of the country, Iron Age people also preferred to settle on the saddle (or neck) between mountains (hills/outcrops), outcrops and the foot of hills. These areas should also be avoided.
- Avoid all patches bare of vegetation unless previously inspected by an archaeologist. These might be old settlement sites.
- Rock outcrops might contain rock shelters, engravings or stone walled settlements, and should therefore be avoided unless previously inspected by an archaeologist.
- Communities living close to the proposed corridor should be consulted as to the existence of sites of cultural significance, e.g. graves, as well as sites that do not show any structures but have emotional significance, such as battlefields, etc.
- All graves or cemeteries should be avoided, where practically possible. The correct procedure, i.e. notification of intent to relocate them, consultation with descendants and permit application, should then be followed in relocating the graves. If any of the graves are older than 60 years, they can only be exhumed by an archaeologist. Graves of victims of conflict require additional permits from SAHRA before they can be relocated.

4.2.5 Risk

The sensitivity analysis was based on the catastrophic failure of a single 1.8 diameter pipeline from the gas cleaning unit to the CCGT plant. The process conditions of the pipeline used in the study were:

- Pressure: 15 bar (g)
- Temperature: 40 ºC