Annex G.9

Climate Change Specialist Report
Black Mountain Mining (Pty) Ltd

Vedanta Gamsberg ESIA

Climate Change Specialist Study

February 2013

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DECLARATION OF THE CONSULTANT’S INDEPENDENCE

The author of this report, Kevin Tarr-Graham, does hereby declare that he is an independent consultant and has no business, financial, personal or other interest in the activity, application or appeal in respect of which he was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of the specialist performing such work. All opinions expressed in this report are his own.

Kevin Tarr-Graham
April 2013
**LIST OF ACRONYMS**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>BMM</td>
<td>Black Mining Mountain (Pty) Ltd</td>
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<td>CDM</td>
<td>Clean Development Mechanism</td>
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<tr>
<td>CER</td>
<td>Certified Emissions Reductions</td>
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<tr>
<td>CH₄</td>
<td>Methane</td>
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<td>CO₂</td>
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<td>CRA</td>
<td>Climate Risk Assessment</td>
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<td>Climate Systems Analysis Group</td>
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<td>December January February</td>
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<td>ERM</td>
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<td>ESIA</td>
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<td>FEED</td>
<td>Front End Engineering and Design</td>
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<td>Global Circulation Model</td>
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<td>IFC</td>
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<td>International Standards Organisation</td>
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<td>JJA</td>
<td>June July August</td>
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<tr>
<td>Kg</td>
<td>Kilogram</td>
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<tr>
<td>MAE</td>
<td>Mean Annual Evaporation</td>
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<tr>
<td>MAM</td>
<td>March April May</td>
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<tr>
<td>N₂O</td>
<td>Nitrous Oxide</td>
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<td>PFC</td>
<td>Perfluorocarbon</td>
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<tr>
<td>PS</td>
<td>Performance Standard</td>
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<tr>
<td>SARVA</td>
<td>South African Risk and Vulnerability Atlas</td>
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<td>South African Weather Service</td>
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<tr>
<td>SF₆</td>
<td>Sulphur Hexafluoride</td>
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<tr>
<td>SON</td>
<td>September October November</td>
</tr>
<tr>
<td>WBCSD</td>
<td>World Business Council on Sustainable Development</td>
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<td>WRI</td>
<td>World Resources Institute</td>
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LIST OF UNITS

°C Degrees Celcius
Kg Kilogram
Km² Square kilometres
Km/h Kilometres per hour
kWH Kilowatt Hour
L Litres
mm Millimetre
m/s Metres per second
MW Mega Watt
t Tonne
tCO₂e Tonnes Carbon Dioxide Equivalent
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INTRODUCTION

1.1 BACKGROUND

As part of the Environmental and Social Impact Assessment (ESIA) for Black Mountain Mining (Pty) Ltd’s (BMM) Gamsberg Zinc Mine, ERM conducted a Climate Change Specialist Study comprising two distinct parts:

- A climate risk assessment (CRA); and
- A greenhouse gas (GHG) assessment.

A detailed description of the project is available in Section 1 of the Gamsberg Zinc Mine ESIA Report.

1.2 CONTEXT

Climate change, and the associated political and social response, is already presenting material risks and opportunities to business and industrial sectors. These risks and opportunities have grown in prominence over the last five years and are expected to increase significantly in scale and coverage in the next ten years. Governments are proposing and implementing legislation to mitigate GHG emissions such as carbon taxes, emission limits etc, and the cost of business interruption following extreme weather events is increasing the need for implementation of adaptation measures.

In this context, forward thinking business and governments are beginning to identify their exposure to climate change issues, understand the financial implications and develop mitigation strategies and adaptation response plans in order to ‘climate ready’ their operations going forward. The physical impacts of climate change are accelerating and pose a threat to business operations and financial earnings through extreme weather events such as storms and droughts. The effect of these changes could result in business interruption through damage to physical assets and disruption to supply chains and distribution networks.

In recognition of this, the IFC Performance Standards (2012) explicitly require that new projects assess climate change risk and understand GHG emissions and energy use:

- **IFC Performance Standard 1** (Assessment and Management of Environmental and Social Risks and Impacts): The risks and impacts identification process will consider the emissions of GHG, the relevant risks associated with a changing climate and the adaptation opportunities, and potential transboundary effects, such as pollution of air, or use or pollution of international waterways.
• **IFC Performance Standard 3** (Resource Efficiency and Pollution Prevention) requires:
  
  o measures for improving efficiency in consumption of energy, water, as well as other resources and material inputs;
  
  o options to reduce project-related GHG emissions during the design and operation of the project; and
  
  o for projects > 25,000 tonnes of carbon dioxide equivalent (tCO2e)/year quantification of direct GHG emissions within the physical project boundary and indirect emissions associated with off-site production of energy (ie purchased electricity).

• **IFC Performance Standard 4** (Community Health, Safety and Security): calls for projects to take into account the fact the communities are already subjected to climate change and may also experience an acceleration and/or intensification of impacts from project activities since climate change impacts may exacerbate their vulnerability. As such, projects are encouraged to identify and mitigate risks and potential impacts on priority ecosystems services that may be exacerbated by climate change.

Understanding the nature of these risks will allow new facilities to be designed in a manner which increases resilience and takes advantage of opportunities from the outset thereby reducing costs going forward. In addition, designing a facility with a view to having the lowest possible carbon footprint will reduce exposure to carbon taxes and other potential regulatory risks in the future.

1.2.1 **CRA and GHG Assessment Aims and Benefits in the ESIA Context**

The CRA and GHG assessment for the Gamsberg Zinc Mine are separate but complementary to the Environmental and Social Impact Assessment (ESIA) conducted by ERM. Whilst the ESIA aims to identify and mitigate the impacts of a proposed project on the environment, the CRA looks at the impacts of the environment (and environmental change) on the project. There are a number of key drivers for conducting a CRA and GHG assessment alongside an ESIA for a new development, as summarised below.

• Climate change impacts (as identified through the CRA) may have implications on the environmental performance of a project; for example, if changes in extreme weather events result in damage to facilities that leads to environmental impacts (eg from leaks or damage to equipment and storage facilities).

• Integrating CRA into ESIAs can help to improve the climate resilience of projects and can help to avoid the maladaptation of projects to climate change. Projects failing to consider climate change risks at the planning stages could face severe financial, safety and operational impacts in the
future if climate change impacts bring about the damage or disruption to operations, assets, infrastructure, and energy supply.

- Conducting a CRA and GHG assessment alongside an ESIA offers a valuable opportunity for information on climate change risks, opportunities and implications to feed in to project design considerations. The earlier climate change (including the need to minimise carbon emissions) considerations can be considered, the easier and less costly it is likely to be to adapt projects to the impacts of climate change, and the lower the climate change-induced liability will be on the project.

- Projects conducting a CRA and GHG assessment as part of the ESIA process are likely to be identified by stakeholders as being forward-looking and responsible, bringing about reputational benefits.

1.2.2 Objectives

This Climate Change Specialist Study has the following objectives:

- undertake a high level assessment of the physical risks facing the development, such as higher temperatures, floods, strong winds etc, and identify adaptation measures that could reduce the risk or take advantage of opportunities; and

- estimate the operational carbon footprint of the proposed Gamsberg Zinc Mine, identify high level opportunities for minimising the carbon footprint, and understand exposure to regulation such as carbon taxes.

1.2.3 Project Description

Project Location

The Gamsberg Zinc Mine is located between the towns of Aggeneys and Pofadder, approximately 120 km east of the Springbok, along the N14 in the Northern Cape (Figure 1.1). The mine and plant site will be located on properties Bloemhoek 61 Portion 1, Gams 60 Portion 1, Aroams 57 RE and Gams 60 Portion 4, approximately 14 km east of the town of Aggeneys, along the eastern border of the N14.

The existing gravel road from Gamsberg to the Sishen-Saldanha railway line, at Loop 10 railway siding, is located approximately 160 km east of the Gamsberg mine. The Loop 10 siding and associated infrastructure is the property of BMM.

Through optimising existing infrastructure of the Loop 10 Road, N14 and railway lines, BMM intends to transfer the zinc concentrate from the mine to the Port of Saldanha, if this is selected as the preferred port of export. The presence of existing transportation infrastructure provides a strategic
advantage and market viability for BMM, while limiting the footprint of the proposed development. The Port of Saldanha, however, has not been included in the scope of the project.
Figure 1.1   Project Location
Project Components

The proposed project will comprise the following components:

- Mine machinery fleet;
- Workshops;
- Transport links;
- Waste rock dumps;
- Tailings facility;
- Stockpile areas;
- Concentrator plant;
- Supporting infrastructure such as water supply, energy supply, laboratories, sewage works and office complex;
- Conveyor system;
- Water storage dams;
- Temporary storage facilities;
- Mine pit;
- Saldanha port facility;
- Offsite linear infrastructure in the form of energy and water supply, and transport routes; and
- Staff housing.

1.2.4 Report Structure

The remainder of this report is structured as follows:

Section 2: Climate Change Risk Assessment

- Section 2.1 – provides a short overview of the aims of the CRA.
- Section 2.2 – introduces the rationale behind conducting a CRA.
- Section 2.3 – describes the methodology adopted for the CRA detailing both the CRA process and the ESIA impact assessment methodology and the relationship between the two.
- Section 2.4 – sets out step 1 of the CRA process, namely the scope for the assessment. Here the project location, project components, project lifespan and relevant climate variables to be assessed are discussed.
- Section 2.5 - introduces step 2 of the CRA process starting with the climate baseline based on the analysis of historic weather data. Thereafter, the climate change projections for the project area and the climate scenarios are discussed.
- Section 2.6 – defines the climate change-related risks to the project as identified based on the baseline and climate change scenarios.

1 Not included in the scope of work.
• **Section 2.7** – assess the impact that the identified climate change-related risks will likely have on the project.

• **Section 2.8** – describes possible mitigation measures to reduce the likelihood of the impacts or avoid the impact altogether.

*Section 3: Greenhouse Gas Assessment*

• **Section 3.1** – outlines ERM’s approach to undertaking this study and provides details of the methodology used to estimate the carbon footprint and assess the impacts.

• **Section 3.2** – describes the aspects of the project considered to be within the scope of this study with particular reference to the definition of the boundary within which the carbon footprint is to be estimated.

• **Section 3.3** – describes the affected environment in relation to current greenhouse gas emissions in South Africa and the projected emissions.

• **Section 3.4** – describes the estimated carbon footprint from the Gamsberg facilities and the estimated carbon tax exposure.

• **Section 3.5** – identifies applicable policies, legislation, standards and guidelines which may affect Gamsberg’s operations in South Africa with regards to climate change and greenhouse gases.

• **Section 3.6** – assesses the impact of the increase in GHG emissions from the Gamsberg facilities on the National GHG emissions, and provides a comparison with emissions from similar facilities globally.

• **Section 3.7** – provides recommendations on management of GHG emissions and alternative design and/or operational activities which could lead to a reduced footprint.

• **Section 3.8** – provides recommendations on monitoring of GHG emissions in the future.
2.1 OVERVIEW

This section presents the findings of the climate risk assessment (CRA) and review of adaptation (impact mitigation) options for the Gamsberg Zinc Mine. The objectives of the CRA are to:

- identify the principal climate-related risks to the Gamsberg Zinc Mine across the timescale of the project;
- prioritise the principal climate-related risks; and
- identify potential mitigation measures that could reduce risk or take advantage of opportunities (ie climate change adaptation1).

It should be noted that the development of this report was conducted simultaneously with the development of the hydrology, groundwater and surface water reports and, as such, the results of those studies should be read with an understanding of how the climate is likely to change in the future.

2.2 RATIONALE FOR THIS ASSESSMENT

Human-induced climate change is one of the most complex and serious challenges confronting the world today. Amongst other things, the burning of fossil fuels to generate energy, the release of carbon from soil into the atmosphere when land is ploughed, the mining of calcium carbonate for cement production, the release of methane from farm animals and landfills, the emission of industrial gases, and the deforestation of forested areas that sequester atmospheric carbon dioxide (CO₂) all increase the concentration of atmospheric greenhouse gases (GHGs). This in turn increases the retention of solar radiation within the atmosphere, raises the temperature and destabilises the global climate system (Figure 2.1).

Climate change has already begun to affect physical and biological systems, including people. On average, the world is currently 0.74°C warmer than it was 100 years ago. ‘Without further commitments and action to reduce greenhouse gas emissions, the world is likely to warm by more than 3°C above the preindustrial climate. Even with the current mitigation commitments and pledges fully implemented, there is roughly a 20 percent likelihood of exceeding 4°C by 2100. If they are not met, a warming of 4°C could occur as early as the 2060s’. ‘A 4°C world would

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1 Climate change adaptation in the context of capital project development can be thought of as activities to avoid, minimise or mitigate the business risks arising from extreme weather events and/or gradual changes in climate. Adaptation measures include altering physical design of the mine site or infrastructure, implementing business procedures, and altering operating patterns.
be one of unprecedented heat waves, severe drought, and major floods in many regions, with serious impacts on ecosystems and associated services’.

The term ‘climate’ is used to describe the weather conditions that characteristically prevail in a particular region i.e., the average weather conditions in a region over a long period of time (around 30 years). On a short-term or day-to-day basis, we experience ‘weather’, which is characteristic of the climate at a given point in time (usually hours or days) in terms of variables such as temperature, humidity, precipitation, cloudiness, wind, and atmospheric pressure. At times, weather can impact human activities, often through a ‘weather event’ such as a storm, heatwave, heavy precipitation, wind gusts etc., in which we experience the climate variable within a relatively concentrated or intense period of time. ‘Extreme’ weather events are unusual, severe or unseasonal weather events occurring at the extremes of what has been seen historically. In this document, we discuss identifying, assessing, evaluating and managing the risks associated with both weather events and more gradual long-term changes in climate (climate change), collectively known as climate risk.

Figure 2.1 The Greenhouse Effect (IPCC, 2007)

Business Risk from Extreme Weather and Climate Change

It is critical that Verdanta manages business risks arising from extreme weather events and climate variability (i.e., climate risk) to minimise disruption to operations including (but not limited to) supply chains, water supplies, transport networks, and energy supplies.
2.3 **Methodology**

The CRA was conducted by reviewing historic data on climate and weather events in the project region and surrounding towns, and overlaying the findings with peer-reviewed scientific projections of climate change in order to assess and identify future climate risk and opportunities for the project. Key interactions between project components and climate risk sources were subsequently analysed and prioritised.

The CRA followed the five-step process as discussed below and as outlined in Figure 2.2.

**Figure 2.2 The Five-step CRA Process**

**CRA Step 1: Project Scoping (Section 2.4)**

Step 1 of the CRA assessed the location of the Gamsberg Zinc Mine, the project’s assets and temporal scale (ie timelines and project components). The relevant climate variables to be assessed during the CRA were also determined during the Project Scoping exercise. During this step, the likely interactions between the project and the climate were identified in order to focus the risk assessment.

**CRA Step 2: Climate Baselines and Scenarios (Section 2.5)**

During Step 2, the weather conditions of the project’s location (ie the climate baseline) were determined following the analysis of historic weather data. Thereafter, peer-reviewed climate change projections were sourced for the region in order to determine the likely future climate scenarios over the project lifetime.

**CRA Step 3: Define Climate-related Risks (Section 2.6)**
Based on the findings of Step 2, the key climate-related risks to specific project components or activities were identified during Step 3.

**CRA Step 4: Risk Scoring (Section 2.7)**

During this Step, the significance of each climate-related impact on the project was assessed using a customised version of the ESIA impact assessment methodology as set out in Section XX in the main Gamsberg Zinc Mine ESIA report. The methodology is discussed further below.

**CRA Step 5: Risk Mitigation (Section 2.7.1)**

Based on the risks identified and prioritised, appropriate adaptation measures to mitigate the impacts and risks were identified during Step 5.

2.4 **CRA STEP 1: CRA SCOPE**

The BMM scoping report developed by ERM was used to inform the CRA scoping exercise. Project location and component details are contained within Section 1.2.3 of the CRA.

The CRA focused on the following project components and identified the specific risks to these:

- Safety;
- Air quality Controls;
- Mine Infrastructure and Facilities;
- Transport Network;
- Community Support;
- Energy/Power Supply;
- License to Operate;
- Supply Chain;
- Water Capture, Recycling, Treatment and Disposal;
- Health;
- Tailings Facility; and
- Waste Rock facility.

These components were selected for the CRA based on ERM’s experience with climate impacts in the mining sector as well the duration of time these components would be present/‘active’ on site during the project lifetime.

**Project Temporal Scale**

The project lifetime comprises the following phases:

- Planning and design;
- Construction;
- Operational (to span approximately 20 years to 2035); and
Decommissioning phases.

Decommissioning is expected to commence in 2036 with the completion dates to be determined during the ESIA Phase.

Climate Variables to be Considered

The following climate-related variables and weather events were investigated as part of the CRA:

- Air temperature;
- Precipitation levels;
- Windspeed;
- Relative humidity;
- Evaporation;
- Storms (including lightning storms)
- Heavy rainfall;
- Flooding (flash flooding and flooding of the Orange River); and
- Drought.

Given the location of the project site, preliminary research results and data availability, this study focusses on those variables with a potential to adversely impact project activities (eg the inland location means there is no risk from sea level rise, cyclones and storm surges and the topography means the landslide risk is very low).

A key consideration when conducting the scoping exercise was the timescales of the project activities in different project geographies. This is because climate change risks and opportunities are likely to increase in magnitude and frequency with time, meaning that activities with longer timeframes should be focused on. Project activities with shorter timescales, including planning and design, were deemed to be lower priority than project activities with longer timescales, namely Operations (spanning over 20 years to 2035).

2.5 CRA STEP 2: DEVELOP CLIMATE BASELINE AND SCENARIOS

2.5.1 Introduction

In order to understand future climate risk in the area of the Gamsberg Zinc Mine, the existing climate was assessed to create a baseline against which future climate change were measured. This then fed into the risk assessment in Step 3.

2.5.2 Methodology

The climate baseline reflects recent climate in a region. In order to construct a climate baseline for a region, the following examples of historical data on
climate variables and extreme weather events were consulted from a number of sources:

- Precipitation information was sourced from the client for the nearby town of Pella;
- Precipitation and evaporation data for the catchment area around the project site were sourced from the client;
- Baseline weather data (including precipitation, wind speed and temperature) were purchased from the South African Weather Service (SAWS) for the nearby town of Pofadder (and precipitation data for Aggeneys); and
- Information on reported weather events/incidences for South Africa (including incidences reported in Springbok, Augrabies, Pofadder, Kakamas and Upington) was also sourced from SAWS (see Figure 2.12).

The climate scenarios were generated using peer-reviewed scientific research on the impacts of climate change, including the South African Risk and Vulnerability Atlas (SARVA), Intergovernmental Panel on Climate Change (IPCC) Assessment Reports, as well as the IPCC’s data portal and other studies. As far as possible, projections were sourced for the period during which the mine will be active.

2.5.3 Climate Baseline

Temperature

Gamsberg Zinc Mine is located in the Northern Province of South Africa, a characteristically hot, dry region comprising a portion of the Kalahari Desert. Summers are very hot within the region in which the project site is situated with mean maximum temperatures in the 30s (°C) between November and March\(^1\). January, the hottest month, has a mean temperature of 24.8 °C and a mean maximum temperature of 33 °C\(^2\). During the summer months, daily maximum temperatures regularly exceed 30 °C (Figure 2.3). Between 1961 and 1990, it was recorded that in January, on average, maximum daily temperatures are greater than or equal to 35 °C on nine days out of the month\(^3\). Between 2000 and 2012, average January daily maximum temperatures were greater than or equal to 35 °C on 12 days of the month (Figure 2.3).

---

\(^1\) Based on data for Pofadder from 1961 – 1990 (SAWS WB42).
\(^2\) Based on data for Pofadder from 1961 – 1990 (SAWS WB42).
\(^3\) Based on data for Pofadder from 1961 – 1990 (SAWS WB42).
The mean maximum temperature during January between 2000 and 2012 has ranged from 30.7 to 35.4 °C, and has shown a general trend of increasing by approximately 2.8 °C over that period of time (Figure 2.4).

During winter, mean maximum temperatures range from 17.8 to 20 °C; days are cool and nights are cold. June is the coolest month with a mean temperature of 12.1 °C and a mean maximum temperature of 17.8 °C.

Temperatures in Pofadder range from an absolute minimum of -3 °C to a maximum of +40.8 °C based on historic records from 1961 - 1990 and 2000 - 2012. The Gamsberg Zinc Mine is located in one of the hotter and driest regions in South Africa as illustrated in Figure 2.5 and Figure 2.6.

---

1 Pofadder, based on data from SAWS for 2000 – 2012.
Figure 2.4  Mean Maximum Temperature in Pofadder for January between 2000 to 2012

Figure 2.5  Average Annual Temperatures over South Africa (SARVA, 2011)\(^1\)

\(^1\)Based on data from 1961-1990.)
Evaporation

Mean annual evaporation (MAE) in the area is 2,650 mm and average monthly evaporation is set out in Table 2.1 below.

Table 2.1 Average Monthly Evaporation (mm)

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean evaporation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>355</td>
</tr>
<tr>
<td>February</td>
<td>290</td>
</tr>
<tr>
<td>March</td>
<td>259</td>
</tr>
<tr>
<td>April</td>
<td>184</td>
</tr>
<tr>
<td>May</td>
<td>129</td>
</tr>
<tr>
<td>June</td>
<td>98</td>
</tr>
<tr>
<td>July</td>
<td>101</td>
</tr>
<tr>
<td>August</td>
<td>137</td>
</tr>
<tr>
<td>September</td>
<td>189</td>
</tr>
<tr>
<td>October</td>
<td>253</td>
</tr>
<tr>
<td>November</td>
<td>304</td>
</tr>
<tr>
<td>December</td>
<td>351</td>
</tr>
</tbody>
</table>

Precipitation

The site of the Gamsberg Zinc Mine falls within both the summer precipitation Bushmansland and winter precipitation Namaqualand regions.

There is typically little precipitation in the project region, with Aggeneys (the town closest to the project area) receiving an average of 110 mm of precipitation per annum\(^1\), Pella receiving an average of 77 mm\(^2\), and Pofadder receiving an average of 117 mm per annum. The Gamsberg region receives greater than 75 percent of its annual precipitation between January and June (± 68 mm) with January and April receiving the most precipitation\(^3\). Aggeneys experiences its highest mean monthly precipitation in April (approximately 24 mm) (Figure 2.7). Pofadder received its maximum monthly precipitation (146 mm) in February 1974, with its maximum 24 hour precipitation of 77 mm (experienced on 21 February 1974) contributing to this\(^4\). Mean monthly precipitation in Pofadder in February is 22 mm. In general, annual precipitation in the region is highly variable (Figure 2.8).

---

1 Based on data from data from 1986 – 2012.
2 Based on data from 1878 – 1980.
3 Information from the Draft Scoping Report.
4 Pofadder WB42 from SAWS.
Figure 2.6  Average Annual Precipitation over South Africa (SARVA, 2011)

Figure 2.7  Average Monthly Precipitation in Aggeneys (1986 - 2012)

Based on data from 1961-1990.

\(^1\) Based on data from 1961-1990.
Since 1920, snow has been recorded, in the South African Weather Service (SAWS) CAELUM Report, within the greater region in which the project lies on four occasions\(^1\). Records show snow fall three times in Springbok (1953, 1988 and 1994) and once in Upington (1983). Hail has been recorded twice since 1920, once in Augrabies in 1991 and once in Upington in 2002 (Figure 2.12).

**Flooding**

The rivers in the mine site are ephemeral (ie only flow following rainfall) and drainage is endorheic (ie water seeps into the earth rather than flowing into another river/the sea). It is understood that water drains quickly and does not pond for long. Flash flooding has also occurred within the mine site although the frequency is not known. The maximum flood in the mine site catchment is (Directorate of Water Affairs, 1980):

- Northern Catchment: 133 m\(^3\)/s; and
- Southern Catchment (Inselberg): 99 m\(^3\)/s.

Analysis of extreme weather events in the Northern Cape between 1920 - 2011 indicated that severe flooding has been experienced in Upington, Kakamas, Augrabies and Springbok two to three times per decade (SAWS, 2011). Of the 50 flooding events that have occurred in the Northern Cape since 1920, 20 of them occurred in towns situated on the Orange River. Flooding is a rare occurrence in towns further away from the river – one incident was recorded in Springbok 1994.

Flooding of the Orange River occurs in this area when there has been significant precipitation inland and the river struggles to contain the flow.

\(^1\) It should be noted that it is possible that not all snow and hail weather events are captured within the SAWS CAELUM Report as it depends on a SAWS representative experiencing and reporting the event.
within its huge catchment (approximately 1 million km²). The most recent and one of the more severe events occurred in January 2011 inundating the flood plain and resulting in the devastation of arable land and the evacuation of families in Upington, Kakamas and Augrabies (see Figure 2.9, Figure 2.10 and Figure 2.11).

The incidences of flooding and other extreme weather events in the region surrounding the project area are plotted in Figure 2.12 which shows recorded events in the Northern Cape between 1920 and 2011 based on information contained in the SAWS CAELUM report. The CAELUM report is a report developed by SAWS capturing all of the extreme weather events that have been recorded/reported within South Africa since 1913. The report contains details of the event, including event type, location, date and any additional information available (eg deaths, rand value associated with the damage of the event, infrastructure damaged etc).

It should be noted that it is possible that not all extreme weather events are captured within the SAWS CAELUM Report as it depends on a SAWS representative experiencing and reporting the event. It is, however, the best available source of data on such events from SAWS. Additionally, although an extreme event, snow for example, was recorded in one town it is likely that that event was also experienced in other, smaller, towns within the region in which the project is situated but that the event was not recorded in the other towns given their size.

Figure 2.9 The 2011 Flooding of the Orange River Destroyed Hundreds of Hectares of Arable Land in Upington (Swanepoel, 2011)
Figure 2.10  The 2011 Flooding of the Orange River Caused Significant Damage to Infrastructure and Blocked Transport Routes in Upington (Swanepoel, 2011)

Figure 2.11  The Impact of the 2011 Flooding of the Orange River on the Augrabies Falls (Marcus, 2011)
Relative Humidity

Relative humidity in the area is highest over the winter months, during which time humidity has been known to reach a maximum of 96 percent (with June being the most humid month on average) in Pofadder (SAWS, 2012). Average humidity is also greatest in the morning with average annual humidity being 59 percent at 08h00.

Wind Speed

Wind speeds within the area are typically low, with monthly average wind speeds ranging from 3.3 m/s to 4.3 m/s (11.9 – 15.5 km/h) at 14h00 based on information for Pofadder from between 2000 - 2012. The maximum gust speed recorded in Pofadder between 2008 – 2012 was 30.7 m/s (110.5 km/h) during February. Average gust speed during the year is 11.23 m/s (40.43 km/h).

Summary

The climate in the Gamsberg Zinc Mine area is typically hot and dry with very little precipitation throughout the year.

Extreme weather events are not characteristic of the region and the mine site in particular and those that have taken place do not appear to have had a significant impact apart from flooding in towns along the Orange River. Figure 2.12 provides a summary of recorded extreme weather events in the Northern Cape from 1920 to 2011. A full summary of the climate baseline for the area is provided in Table 2.2 after the climate change projections section.
Figure 2.12  Recorded Weather Events Around the Project Site (SAWS, 2011)

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Event</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1925</td>
<td>Mar</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1934</td>
<td>Jan</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1941</td>
<td>Jan</td>
<td>FLOODS</td>
<td>Kakamas</td>
</tr>
<tr>
<td>1941</td>
<td>Jan</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1948</td>
<td>Apr</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1953</td>
<td>Jul</td>
<td>SNOW</td>
<td>Springbok</td>
</tr>
<tr>
<td>1955</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Kakamas</td>
</tr>
<tr>
<td>1957</td>
<td>Sep</td>
<td>FLOODS</td>
<td>Kakamas</td>
</tr>
<tr>
<td>1964</td>
<td>Feb</td>
<td>STRONG WIND</td>
<td>Upington</td>
</tr>
<tr>
<td>1965</td>
<td>Mar</td>
<td>STRONG WIND</td>
<td>Upington</td>
</tr>
<tr>
<td>1966</td>
<td>Jan</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1967</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Kakamas</td>
</tr>
<tr>
<td>1967</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1974</td>
<td>Mar</td>
<td>FLOODS</td>
<td>Kakamas</td>
</tr>
<tr>
<td>1974</td>
<td>Mar</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1976</td>
<td>Mar</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1981</td>
<td>Aug</td>
<td>SNOW</td>
<td>Pofadder</td>
</tr>
<tr>
<td>1981</td>
<td>Aug</td>
<td>SNOW</td>
<td>Upington</td>
</tr>
<tr>
<td>1985</td>
<td>Dec</td>
<td>STRONG WIND</td>
<td>Kakamas</td>
</tr>
<tr>
<td>1988</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Augrabies</td>
</tr>
<tr>
<td>1988</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1988</td>
<td>Apr</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1988</td>
<td>Jul</td>
<td>SNOW</td>
<td>Springbok</td>
</tr>
<tr>
<td>1991</td>
<td>Oct</td>
<td>HAIL</td>
<td>Augrabies</td>
</tr>
<tr>
<td>1994</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Springbok</td>
</tr>
<tr>
<td>1994</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Springbok</td>
</tr>
<tr>
<td>1994</td>
<td>Feb</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
<tr>
<td>1994</td>
<td>Jun</td>
<td>SNOW</td>
<td>Springbok</td>
</tr>
<tr>
<td>1996</td>
<td>Apr</td>
<td>FLOODS</td>
<td>Kakamas</td>
</tr>
<tr>
<td>2002</td>
<td>Dec</td>
<td>HAIL</td>
<td>Upington</td>
</tr>
<tr>
<td>2006</td>
<td>May</td>
<td>HEAVY RAIN</td>
<td>Springbok</td>
</tr>
<tr>
<td>2011</td>
<td>Jan</td>
<td>FLOODS</td>
<td>Upington</td>
</tr>
</tbody>
</table>
2.5.4 Projected Future Climate Change

Temperature

Temperatures across all of Africa are projected to increase over the 21st Century (across all seasons\(^1\)) and the warming is anticipated to exceed the global mean annual temperature increase (SARVA, 2011), which is projected to be approximately 3.4 °C by 2100\(^2\). In South Africa, warming is expected to be greatest over the northern and central parts (within which the project area falls) and lower along the coast.

The South African Risk and Vulnerability Atlas (SARVA) indicates that mean temperatures within the project area could increase across all seasons by the end of the century with the greatest increase occurring during autumn (March – May) (Figure 2.13). Warming across seasons could be within the range of 2.5 to 3.5 °C by 2070 – 2100 compared with a baseline from 1975 – 2005. Summer temperatures are expected to warm by approximately 2.5 °C by 2100\(^3\) (SARVA, 2011).

---

\(^1\) By between 3°C and 4°C by 2100 compared to the 1980 – 1999 period.
\(^2\) Based on a baseline from 1980 – 1999, based on the A2 scenario (IPCC AR4, 2007).
\(^3\) Based on the dynamic regional climate model (Engelbrecht et al. 2009) under the A2 emission scenario (that assumes a moderate to high growth in GHG concentrations) of the Special Report on Emissions Scenarios.
According to the World Bank Climate Change Knowledge Portal, mean temperature within the project area is expected to increase within the project lifetime (i.e. by 2020-2039) by approximately 1 °C reaching up to 27 °C in January as shown in Figure 2.14. The projected change in temperature is relatively low given the shorter timeframes analysed.

---

1 Based on the dynamic regional climate model (Engelbrecht et al. 2009) under the A2 emission scenario (that assumes a moderate to high growth in GHG concentrations) of the Special Report on Emissions Scenarios. The changes are for the period 2070-2100 compared to 1975-2005. For each of the seasons, the 75th percentile was calculated for each of the present-day and future time series of the seasonal averages.
An increase in temperature is corroborated by downscaled monthly maximum temperature projections for Pofadder from the Climate Systems Analysis Group (CSAG) where temperatures are shown to increase by up to 2.5 °C by 2046 - 2065 compared with the baseline from 1961 – 2000 (CSAG, 2013) (Figure 2.15).

Indeed, extrapolating the trend line based on the mean maximum temperatures for Pofadder in January (Figure 2.4) demonstrates that mean maximum temperatures during January are likely to come close to reaching 37°C (Figure 2.16). Additionally, the average number of days exceeding 30, 35
and 40°C during the summer months are likely to increase should temperatures increase by 2.5°C (Figure 2.17). Most notable is the difference in the number of days exceeding 35°C - an average of 11.2 per month at present vs an average of 22.6 per month in the future. Hence, as a result of climate change the number of extreme hot days is projected to increase.

**Figure 2.16** January’s Mean Maximum Temperatures Extrapolated to 2020

![Figure 2.16](image1)

**Figure 2.17** Projected Increased in Days with Temperatures over 30, 35 and 40°C given a 2.5°C Increase in Temperature Against the Baseline Number of Days

![Figure 2.17](image2)

**Precipitation**
Projections of mean annual precipitation are less certain than those related to temperature change. IPCC projections (2007) indicate that precipitation in the southern African region may decline by between 10-20 percent by 2050 as a result of climate change. However, precipitation projections are frequently inconclusive, partly because the Global Circulation Models (GCMs) are unable to reproduce the mechanisms largely responsible for precipitation (such as sea surface temperatures, dust aerosols, deforestation and soil moisture) or account for orography (IPCC, 2007).

Within the project area, by mid-century (2046-2065) precipitation is likely to remain unchanged across all seasons according to SARVA (low resolution data) as illustrated in Figure 2.18. However, projections from the World Bank (high resolution data) suggest that precipitation in the project area, particularly over the winter months, will decline as illustrated in Figure 2.19.
Figure 2.18  Projected Seasonal Precipitation Change (mm) Downscaled from a Number of GCMs for the Period 2046-2065 vs 1961 – 1990¹ (SARVA, 2011)

¹ Projected precipitation downscaled from a number of GCMs of the CMIP3 archive under the A2 SRES scenario. These scenarios reflect the 75th percentile of the model’s projected seasonal precipitation changes.
The median duration of dry spells (related to both temperature and precipitation) for the mid-21\textsuperscript{st} Century over the western and northern regions of South Africa (in which the project site falls) is expected to increase between spring and autumn, compared with 1961 – 1990. SARVA also projects that dry spells of relatively long duration may be expected to occur more frequently (SARVA, 2011).

**Flooding**

Precipitation over the Drakensberg Mountains (the source of the Orange River) and other parts of the Orange River’s extensive catchment area (over 1 million km\(^2\) in size; Figure 2.20) is projected to increase across all seasons, according to SARVA, and specifically by 10 - 50 mm during spring and summer by 2046 - 2065 (Figure 2.18) which may result in additional flooding within the lower reaches of the Orange River during summer.

\(^{1}\) Based on the A2 Scenario, CGCM3.1 GCM model.
A change in windspeed as a result of climate change is expected but there is model disagreement on the direction of change (i.e., positive or negative). Average annual eastward winds, for example, are projected to change by -0.13 m/s (0.5 km/h) to +0.04 m/s (0.14 km/h) by 2011 – 2030 against the baseline from 1961 – 1990 according to three different GCMs (IPCC, 2012).

Summary

Overall, it is projected that the area in which the Gamsberg Zinc Mine is situated is likely to get hotter and drier with increasingly variable precipitation as a result of climate change. Additionally, flooding along the Orange River may become more common given projected increases in precipitation over the River’s source and catchment area.
Table 2.2 summarises the climate baseline and scenarios for the Gamsberg Zinc Mine.
### Table 2.2 Climate Baseline and Scenarios

<table>
<thead>
<tr>
<th>Climate Risk Source</th>
<th>Headline</th>
<th>Baseline</th>
<th>Climate Change Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation Intensity</td>
<td>Precipitation intensity is likely to remain low.</td>
<td>7 days per year where precipitation exceeds 5 mm. 1 day per year, on average, where precipitation exceeds 30 mm (SAWS, 2012). The maximum recorded daily precipitation experienced in the area is 77 mm received in February 1974.</td>
<td>Precipitation intensity unlikely to change significantly.</td>
</tr>
<tr>
<td>Average Precipitation (mm/month)</td>
<td>Average precipitation is likely to remain low. Increasing temperatures may result in increased evaporation levels, thereby reducing surface water availability.</td>
<td>Average precipitation levels for Aggeneys between 1961 and 1990 are (SAWS, 2000 – 2012a): DJF (summer): 13 mm/month; MAM (autumn): 9 mm/month; JJA (winter): 6 mm/month; and SON (spring): 4 mm/month.</td>
<td>Precipitation projections for the project area are inconsistent. Some sources report that at a low resolution the amount of precipitation received within the project area is unlikely to change. Others (ie The World Bank Group, 2013; Figure 2.19) suggest that on average precipitation will increase over the summer months by 3 mm / month and will decrease over the winter months by 3.7 mm/month.</td>
</tr>
<tr>
<td>Average Air Temperature (°C)</td>
<td>Average air temperatures are projected to increase across all seasons, possibly leading to an increase in evaporation levels.</td>
<td>Maximum air temperatures in the region between 1961 and 1990 were (SAWS, 2012): DJF: 40.6°C; MAM: 39.2°C; JJA: 27.1°C; and SON: 36.2°C.</td>
<td>Air temperatures in the region are projected to increase across all seasons. By 2020 – 2039, average temperature in January is projected to reach 27°C compared with a baseline of 26°C (1990 – 2009). Overall, air temperatures are expected to increase by 2.5°C over the summer months by 2070 – 2100 compared with a baseline from 1975 – 2005. The projected increase in the number of extreme hot days over summer is as follows: 86 days ≥ 30°C (increase of 7.5 days from baseline);</td>
</tr>
<tr>
<td>Climate Risk Source</td>
<td>Headline</td>
<td>Baseline</td>
<td>Climate Change Scenario</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Evaporation</td>
<td>Given the projected increase in temperatures, it is likely that evaporation levels will increase.</td>
<td>33.4 days ≥ 35°C; and 0.5 days ≥ 40°C.</td>
<td>67.6 days ≥ 35°C (increase of 34 days from baseline); and 9 days ≥ 40°C (increase of 8.7 days from baseline).</td>
</tr>
<tr>
<td></td>
<td>Evaporation levels are currently high. Average monthly evaporation levels (mm) were (WRC, 1990):</td>
<td></td>
<td>Unknown.</td>
</tr>
<tr>
<td>Wind Speeds (m/s)</td>
<td>Very minor changes in windspeed possible but direction of change is unknown (some model disagreement).</td>
<td>Average wind speeds in Pofadder between 2000 and 2012 were (SAWS, 2000 – 2012b):</td>
<td>Average annual eastward winds are projected to change by -0.13 m/s to + 0.04 m/s by 2011 – 2030 against the baseline from 1961 – 1990 according to three different GCMs (IPCC, 2012).</td>
</tr>
<tr>
<td></td>
<td>DJF: 3.5 m/s; MAM: 3.4 m/s; JJA: 4 m/s; and SON: 3.9 m/s.</td>
<td></td>
<td>There is model disagreement on the direction of change for each month.</td>
</tr>
<tr>
<td></td>
<td>Maximum wind gust speeds in Pofadder between 2008 and 2012 were:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DJF: 14.2 m/s; MAM: 11.5 m/s; JJA: 11.5 m/s; and SON: 13.2 m/s.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Humidity (percent)</td>
<td>The change in relative humidity is unknown. However an increase in</td>
<td>Average seasonal humidity in Pofadder between 1961 and 1990 was:</td>
<td>Unknown.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Climate Risk Source

<table>
<thead>
<tr>
<th>Climate Risk Source</th>
<th>Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature and reduction in precipitation</strong> could lead to a reduction in humidity.</td>
<td>DFM: 52 percent; MAM: 63 percent; JJA: 65 percent; and SON: 54 percent.</td>
</tr>
<tr>
<td><strong>Dry Spells</strong></td>
<td>Information regarding the baseline was not available.</td>
</tr>
</tbody>
</table>
| **Flooding** | Flooding of the Orange River is likely to occur more frequently, however, not enough information is available to assess how the frequency/intensity of flooding of the Orange River as well as of flash flooding episodes in the project area might change. Flash flooding may, however, be exacerbated given the increased surface hardening and paving within the mine site (ie reducing rainwater infiltration rates). | Severe flooding has been experienced in Upington, Kakamas, Augrabies and Springbok at least 2.6 times per decade. Of the flooding events that have occurred in the Northern Cape since 1920, 20 of them occurred in towns situated on the Orange River. Flash flooding has also occurred within the project area (pers. comm.) but the frequency of flash flooding is not known/recorded. The maximum flood in the catchments on the mine site is (Directorate of Water Affairs, 1980):  
- Northern Catchment: 133 m$^3$/s; and 
- Southern Catchment (Inselberg): 99 m$^3$/s. | Precipitation within the project area is expected to remain the same or decline meaning the chance of flooding on site could be the same as at present or reduced. However, precipitation within the catchment area of the Orange River is expected to increase across all seasons and by 10 - 50 mm during spring and summer by 2046 – 2065. As a result, flooding of the lower reaches of the Orange River can be expected to occur more frequently. |
2.6 **CRA Step 3: Define Climate-related Risks**

Based on ERM’s experience with climate change risks in the mining industry, an assessment was made of the main risks which the Gamsberg Zinc Mine might face in the future given a change in the climate. The key risks are summarised in Table 2.3 and are based on the findings in Sections 2.5.3 and 2.5.4. Details of individual risks and the associated significance of the impact to the project can be found in the following section.

**Table 2.3** Key Climate-related Risks to the Gamsberg Zinc Mine Project

<table>
<thead>
<tr>
<th>Weather variable</th>
<th>Risk to project</th>
<th>Potential consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>High temperatures</td>
<td>• Health risk to workforce and community.</td>
<td>• Reduced workforce efficiency.</td>
</tr>
<tr>
<td></td>
<td>• Equipment efficiency.</td>
<td>• Potential community unrest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Downtime and delays due to reduced productivity and problems with equipment.</td>
</tr>
<tr>
<td>Fluvial/pluvial flooding</td>
<td>• Compromised water abstraction capabilities (eg through damage to the pumps).</td>
<td>• Water shortage.</td>
</tr>
<tr>
<td></td>
<td>• Flooding of the pit/other mine facilities.</td>
<td>• Reduced production.</td>
</tr>
<tr>
<td></td>
<td>• Overflow of ponds/tailings facilities/leaching.</td>
<td>• Delays.</td>
</tr>
<tr>
<td></td>
<td>• Prevent access to and from the mine (of people and product).</td>
<td>• Environmental permit non-compliance (eg unauthorised discharge and pollution).</td>
</tr>
<tr>
<td>Drought</td>
<td>• Reduced water availability (eg water restrictions as water prioritised for communities).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Increased need of water for dust suppression.</td>
<td>• Reduced production.</td>
</tr>
<tr>
<td></td>
<td>• Evaporation of ponds and dams.</td>
<td>• Delays.</td>
</tr>
<tr>
<td></td>
<td>• Evaporation causing vegetation loss and erosion.</td>
<td>• Environmental permit non-compliance (eg dust pollution).</td>
</tr>
</tbody>
</table>

2.7 **CRA Step 4: Risk Scoring**

2.7.1 **Methodology**

The traditional environmental impact assessment involves analysis of impacts on the environment as a result of project activities. This assessment, on the other hand, is looking at the impact of changing climate conditions on the project and the associated risks to the business.

ERM’s standard methodology for impact assessments (see Section XX of the Main ESIA Report) has been used as the basis for risk scoring and the definitions of some of the key characteristics have been amended to reflect the
specific conditions associated with the assessment of physical climate risks on project/mining activities. The significance of an impact is determined through assessment of the magnitude of an impact against the sensitivity/vulnerability of the receiving environment as described below.

**Magnitude**

Magnitude is determined according to type, extent, duration and scale of the impact. *Table 2.4* defines the characteristics used to assess the significance of impacts in relation to climate risk.

A rating of positive/ negligible/ small/ medium/ large magnitude is assigned based on the characteristics of the impact.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Definition</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>A descriptor indicating the relationship of the impact to the Project (in terms of cause and effect).</td>
<td><strong>Direct</strong> – Impacts that result from a direct interaction between a climate event and the Project (eg heavy rainfall flooding the pit). <strong>Indirect</strong> – Impacts on the project which is not the result of a climate event affecting the project (eg community health affecting workforce). <strong>Induced</strong> – does not apply.</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>The time period over which the project is affected by the impact.</td>
<td><strong>Temporary</strong> – less than one day. <strong>Short-term</strong> one day to one week. <strong>Medium-term</strong> – longer than one week, shorter than a month. <strong>Long-term</strong> - longer than one month. <strong>Permanent</strong> – impact to sustain a number of years and up to the entire life of mine.</td>
</tr>
<tr>
<td><strong>Extent</strong></td>
<td>The reach of the impact.</td>
<td><strong>On-site</strong> – impacts that are limited to the project site. <strong>Local</strong> – impacts that are limited to the project site and adjacent properties. <strong>Regional</strong> - impacts that are affect communities/properties at a regional scale (with implications for the project).</td>
</tr>
<tr>
<td><strong>Scale</strong></td>
<td>The severity of the impact on the Project.</td>
<td>1 – Project functions and/or processes remain <em>unaltered</em>, eg heat stress affects part of workforce. 2 – Project functions and/or processes are <em>somewhat altered</em>, eg wind delays construction/maintenance activities. 3 – Project functions and/or processes are <em>notably altered</em>, eg flooding results in a one day shutdown. 4 – Project functions and/or processes are <em>significantly altered</em>, eg flooding results in a two week shutdown.</td>
</tr>
</tbody>
</table>
Sensitivity/Vulnerability

In a traditional environmental impact assessment, the assessment of sensitivity, vulnerability, and irreplaceability relates to the environment within which the project is located (e.g., will the mine impact sensitive ecosystems?). CRA impact assessments, however, typically assess significance in relation to the magnitude and the likelihood of events given that impacts are not continuous.

Sensitivity/vulnerability has therefore been defined in relation to the frequency and likelihood for the CRA impact assessment, as described in Table 2.5 below. Frequency refers to the frequency of the extreme weather event occurring over the project lifetime and likelihood describes the probability of the project experiencing a negative consequence as a result of the extreme weather event.

Table 2.5 Frequency and Likelihood Definitions for Extreme Event Impacts

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Definition</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Measure of the periodicity of the extreme weather event.</td>
<td>1 – Occurs once in ten years or more.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Occurs once in 5 to 10 years.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – Occurs once in 1 to 5 years.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 – Occurs once a year or more.</td>
</tr>
<tr>
<td>Likelihood</td>
<td>The probability of the project experiencing a negative consequence as a result of the extreme weather event.</td>
<td>Unlikely – the event is unlikely to result in the project experiencing a negative consequence.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possible – the event may well result in a negative consequence for the project.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Likely/certain – the event will result in one or more negative consequences for the project.</td>
</tr>
</tbody>
</table>

The sensitivity/vulnerability of the project to the impact is then determined based on the frequency and likelihood of the impact and described as being high, medium or low, as set out in Table 2.6 below.

Table 2.6 Impact Sensitivity/Vulnerability Rating Matrix

<table>
<thead>
<tr>
<th>Likelihood of experiencing a negative consequence</th>
<th>Frequency of extreme event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlikely</td>
<td>&gt; every 10 years (&gt;10)</td>
</tr>
<tr>
<td></td>
<td>Every 5 – 10 years (5 – 10)</td>
</tr>
<tr>
<td></td>
<td>Every 1 – 5 years (1-5)</td>
</tr>
<tr>
<td></td>
<td>Once a year or more (&gt;1)</td>
</tr>
<tr>
<td>Possible</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Likely/certain</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>High</td>
</tr>
</tbody>
</table>

Significance
Significance is determined using the magnitude and sensitivity/vulnerability rating as per Table 2.7 below.

**Table 2.7 Impact Significance Rating Matrix**

<table>
<thead>
<tr>
<th>Magnitude of Impact</th>
<th>Sensitivity/ Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Small</td>
<td>Negligible</td>
</tr>
<tr>
<td>Medium</td>
<td>Minor</td>
</tr>
<tr>
<td>Large</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Positive consequences will also be assessed but will not be assigned a significance rating.

Thereafter, the **degree of confidence** is determined. The degree of confidence pertains to whether there are any uncertainties in the prediction, for example, where information is insufficient to fully assess the impact. Degree of confidence is expressed as low, medium or high.

The likelihood of the project experiencing a negative consequence is reduced when adaptation measures are in place.

**2.7.2 Impact Assessment Results**

As detailed in Section 2.6, impacts related to temperature, rainfall and associated flooding, and drought were identified. These impacts were assessed using the methodology set out above and under three conditions, namely:

1. the impact under current **baseline weather conditions** (and with currently proposed baseline mitigation measures – if any) (*Table 2.8*);

2. the impact under **future projected climate change conditions**
4. Table 2.9); and

5. the impact with **mitigation measures in place** (}
As a result of the arid climate in which the project site is situated, the likelihood of the identified impacts occurring and having negative consequences on the project is generally low and as such, none of the impacts were assessed to be of major significance to the project. Only one impact was assessed to be of moderate significance to the project under the baseline conditions, namely the impact to the project stemming from erosion and flooding in the pit and surrounding area caused by heavy rainfall which would result in disruption to the operations. By introducing suitable mitigation measures (e.g., implementing flood control measures) the significance of the risk changes from being moderate to being minor.

Those impacts that emerged as being of moderate significance to the project under future predicted climate change conditions were:

**High Temperatures:**
- affecting staff health and potentially productivity;
- physically affecting nearby communities, which may lead to community unrest;
- reducing access to water and affecting subsistence agriculture in nearby communities, which may lead to community unrest;
- reducing the efficiency of equipment, which may compromise productivity;
- and low rainfall compromising water availability within the region, which may result in reduced productivity; and
- resulting in above-average evaporation of the tailings dams requiring extra water for additional dust suppression and potentially leading to the salinisation of soils and associated non-compliance issues.

**Rainfall and Flooding:**
- Flooding in the lower reaches of the Orange River compromising the water abstraction capabilities of the pumps supplying water to the mine potentially resulting in reduced water availability and productivity;
- Heavy rainfall leading to erosion and flooding in the pit and surrounding area causing disruption to operations; and
- Heavy rainfall/flooding events hampering rehabilitation efforts.

Based on the more significant types of impacts, it is advisable that the Gamsberg Zinc Mine invests in mitigation measures that will act to reduce the
influence of hotter temperatures on the mine, its staff and the nearby communities as well as appropriate flood control measures. Examples of appropriate mitigation measures are included in
Table 2.10 and *Table 2.11*.

In terms of the degree of confidence, all temperature-related impacts were considered to be medium confidence whereas all other impacts were determined to be low confidence given the comparatively little amount of climate data available.

It should be noted that this assessment is high level not based on a detailed technical analysis of hydrology in the area or mine lay out/design due to the availability of information and the concomitant timing of this study and other specialist studies (eg surface water hydrology).

It is recommended that these studies be examined and the potential for changes in the climate as outlined in this report considered when reviewing the impact on the project – this is particularly in relation to water availability and flash flooding.
### Table 2.8  Assessment of Impacts under Baseline Weather Conditions

<table>
<thead>
<tr>
<th>Impact and consequence description</th>
<th>Consequence type</th>
<th>Determining magnitude</th>
<th>Magnitude</th>
<th>Determining sensitivity/vulnerability</th>
<th>Sensitivity/vulnerability</th>
<th>Significance (magnitude x sensitivity/vulnerability)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Type</td>
<td>Duration</td>
<td>Extent</td>
<td>Scale</td>
<td>Frequency</td>
</tr>
<tr>
<td>High temperatures may affect staff health (ie lead to heatstroke/ dehydration) and may hamper productivity during the summer months.</td>
<td>Health</td>
<td>Direct</td>
<td>Medium-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Negligible</td>
</tr>
<tr>
<td>High temperatures during summer may physically affect communities around the mine project site, leading to community unrest.</td>
<td>Social/ communities</td>
<td>Indirect</td>
<td>Long-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Negligible</td>
</tr>
<tr>
<td>High temperatures during summer may adversely affect access to water and any subsistence agriculture underway in the communities, leading to community unrest.</td>
<td>Social/ communities; Environment</td>
<td>Indirect</td>
<td>Long-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Negligible</td>
</tr>
<tr>
<td>High temperatures may reduce the efficiency of certain types of equipment utilised by the mine.</td>
<td>Financial – (schedule/ cost)</td>
<td>Direct</td>
<td>Temporary</td>
<td>On-site</td>
<td>Somewhat altered</td>
<td>Small</td>
</tr>
<tr>
<td>High temperatures coupled with low rainfall could compromise water availability within the region (ie by reducing the level of the Orange River and by the introduction of water restrictions). Such conditions would lead to reduced production.</td>
<td>Cost</td>
<td>Indirect</td>
<td>Short-term</td>
<td>Local</td>
<td>Somewhat altered</td>
<td>Medium</td>
</tr>
<tr>
<td>Impact and consequence description</td>
<td>Consequence type</td>
<td>Determining magnitude</td>
<td>Magnitude</td>
<td>Determining sensitivity/ vulnerability</td>
<td>Sensitivity/ vulnerability</td>
<td>Significance (magnitude x sensitivity/ vulnerability)</td>
</tr>
<tr>
<td>-----------------------------------</td>
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<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>High temperatures result in high evaporation rates which result in the evaporation of fluids from the tailings facilities dams as well as vegetation loss. This will result in additional water being required for dust suppression, for example, and could result in salinisation of soils and result in non-compliance.</td>
<td>Environment</td>
<td>Direct</td>
<td>Short-term</td>
<td>On-site</td>
<td>Remain unaltered</td>
<td>Small</td>
</tr>
<tr>
<td>Flooding of the lower reaches of the Orange River may damage the pumps on the River or result in them having to be pulled out of the river to avoid being damaged. Such conditions would lead to reduced production as a result of water abstraction capabilities being compromised.</td>
<td>Cost</td>
<td>Indirect</td>
<td>Short-term</td>
<td>On-site</td>
<td>Notably altered</td>
<td>Medium</td>
</tr>
<tr>
<td>Heavy rain leading to erosion and flooding in pit and surrounding area causing disruption to operations.</td>
<td>Financial (schedule/ cost)</td>
<td>Direct</td>
<td>Short-term</td>
<td>On-site</td>
<td>Notably altered</td>
<td>Medium</td>
</tr>
<tr>
<td>Groundwater contamination from excess run off of water through pit and unauthorised discharge from storage facilities. This may result in reputational risks and/or regulatory infringements.</td>
<td>Environment</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Small</td>
</tr>
<tr>
<td>Flash flooding may prevent access to and from the mine, thereby preventing the transport of product and staff.</td>
<td>Financial (schedule/ cost)</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Somewhat altered</td>
<td>Small</td>
</tr>
<tr>
<td>Impact Description</td>
<td>Environment</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Severity</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Heavy rain will increase the quantity of water draining through waste rock pile leading to unauthorised discharge. This may result in reputational risks and/or regulatory infringements.</td>
<td>Environment</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Small</td>
</tr>
<tr>
<td>Failure of tailings storage as a result of flooding. This may result in reputational risks and/or regulatory infringements.</td>
<td>Environment</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Small</td>
</tr>
<tr>
<td>Rehabilitation efforts may be hampered by an increase in the frequency and/or magnitude of heavy rainfall/flooding events (and also through slope failure).</td>
<td>Financial (schedule/cost)</td>
<td>Direct</td>
<td>Medium-term</td>
<td>On-site</td>
<td>Somewhat altered</td>
<td>Medium</td>
</tr>
<tr>
<td>Strong wind may disrupt construction activity.</td>
<td>Safety</td>
<td>Direct</td>
<td>Temporary</td>
<td>On-site</td>
<td>Remain unaltered</td>
<td>Negligible</td>
</tr>
<tr>
<td>Strong winds could increase dust blown from pit or tailings operations, increase water use for dust suppression and impact nearby communities.</td>
<td>Social/communities</td>
<td>Indirect</td>
<td>Temporary</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Negligible</td>
</tr>
<tr>
<td>Impact description and consequence</td>
<td>Project Stage</td>
<td>Description of scenario and future impacts</td>
<td>Determining magnitude</td>
<td>Determining sensitivity/ vulnerability</td>
<td>Sensitivity/ vulnerability</td>
<td>Significance (magnitude x sensitivity/ vulnerability)</td>
</tr>
<tr>
<td>----------------------------------</td>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>High temperatures may affect staff health (i.e., lead to heatstroke/dehydration) and may hamper productivity during the summer months.</td>
<td>Construction &amp; Operational</td>
<td>Mean temperatures are projected to increase across all seasons, and by up to 2.5 °C in winter. This may impact the likelihood and frequency of the impact.</td>
<td>Direct Long-term Local Remain unaltered Small &gt;1 Possible High</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High temperatures during summer may physically affect communities around the mine project site, leading to community unrest.</td>
<td>Construction &amp; Operational</td>
<td>Mean temperatures are projected to increase across all seasons, and by up to 2.5 °C in summer. This may impact the likelihood and frequency of the impact.</td>
<td>Indirect Long-term Local Remain unaltered Small &gt;1 Possible High</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High temperatures during summer may adversely affect access to water and any subsistence agriculture underway in the communities, leading to community unrest.</td>
<td>Construction &amp; Operational</td>
<td>Mean temperatures are projected to increase across all seasons, and by up to 2.5 °C in summer. This may impact the likelihood and frequency of the impact.</td>
<td>Indirect Long-term Local Remain unaltered Small &gt;1 Possible High</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High temperatures may reduce the efficiency of certain types of equipment utilised by the mine.</td>
<td>Construction &amp; Operational</td>
<td>Details concerning the operating envelope of the mine were not available and hence the information is insufficient to determine significant change to the baseline risk profile.</td>
<td>Direct Temporary On-site Somewhat altered Small &gt;1 Possible High</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact description and consequence</td>
<td>Project Stage</td>
<td>Description of scenario and future impacts</td>
<td>Determining magnitude</td>
<td>Determining sensitivity/ vulnerability</td>
<td>Sensitivity/ vulnerability</td>
<td>Significance (magnitude x sensitivity/ vulnerability)</td>
</tr>
<tr>
<td>-----------------------------------</td>
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<td>--------------------------------------------</td>
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<td>--------------------------------------------------</td>
</tr>
<tr>
<td>High temperatures coupled with low rainfall could compromise water availability within the region (ie by reducing the level of the Orange River and by the introduction of water restrictions). Such conditions would lead to reduced production.</td>
<td>Operational</td>
<td>Mean temperatures are projected to increase across all seasons, and by up to 2.5 °C in summer. Additionally, rainfall is projected to decline in the region under some scenarios. This may impact the likelihood and frequency of the impact.</td>
<td>Indirect</td>
<td>Short-term</td>
<td>Local</td>
<td>Somewhat altered</td>
</tr>
<tr>
<td>High temperatures result in high evaporation rates which result in the evaporation of fluids from the tailings facilities dams as well as vegetation loss. This will result in additional water being required for dust suppression, for example, and could result in salinisation of soils and result in non-compliance.</td>
<td>Operational</td>
<td>Mean temperatures are projected to increase across all seasons, and by up to 2.5 °C in summer. This may impact the likelihood and frequency of the impact.</td>
<td>Direct</td>
<td>Short-term</td>
<td>On-site</td>
<td>Remained unaltered</td>
</tr>
<tr>
<td>Impact description and consequence</td>
<td>Project Stage</td>
<td>Description of scenario and future impacts</td>
<td>Determining magnitude</td>
<td>Determining sensitivity/vulnerability</td>
<td>Significance (magnitude x sensitivity/vulnerability)</td>
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<td></td>
</tr>
<tr>
<td>Flooding of the lower reaches of the Orange River may damage the pumps on the River or result in them having to be pulled out of the river to avoid being damaged. Such conditions would lead to reduced production as a result of water abstraction capabilities being compromised.</td>
<td>Operational</td>
<td>The projected increase in rainfall over the catchment area of the Orange River will result in such circumstances becoming more common.</td>
<td>Indirect</td>
<td>Short-term</td>
<td>On-site</td>
<td>Notably altered</td>
</tr>
<tr>
<td>Heavy rain leading to erosion and flooding in pit and surrounding area causing disruption to operations.</td>
<td>Operational</td>
<td>Information on the frequency of flash flooding and how this might change given climate change is insufficient to determine the climate risk profile of this risk.</td>
<td>Direct</td>
<td>Short-term</td>
<td>On-site</td>
<td>Notably altered</td>
</tr>
<tr>
<td>Groundwater contamination from excess run off of water through pit and unauthorised discharge from storage facilities. This may result in reputational risks and/or regulatory infringements.</td>
<td>Operational</td>
<td>No robust historical analysis of flash flooding frequency currently available for the project area. Hence, information is insufficient to determine significant change to the baseline risk profile.</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Remain unaltered</td>
</tr>
<tr>
<td>Flash flooding may prevent access to and from the mine, thereby preventing the transport of product and staff.</td>
<td>Operational</td>
<td>No robust historical analysis of flash flooding frequency currently available for the project area. Hence, information is insufficient to determine significant change to the baseline risk profile.</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Somewhat altered</td>
</tr>
<tr>
<td>Impact description and consequence</td>
<td>Project Stage</td>
<td>Description of scenario and future impacts</td>
<td>Determining magnitude</td>
<td>Determining sensitivity/vulnerability</td>
<td>Significance</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Type</td>
<td>Duration</td>
<td>Extent</td>
<td>Scale</td>
</tr>
<tr>
<td>Heavy rain will increase the quantity of water draining through waste rock pile leading to unauthorised discharge. This may result in reputational risks and/or regulatory infringements.</td>
<td>Operational</td>
<td>No robust historical analysis of flash flooding frequency currently available for the project area. Hence, information is insufficient to determine significant change to the baseline risk profile.</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Remain unaltered</td>
</tr>
<tr>
<td>Failure of tailings storage as a result of flooding. This may result in reputational risks and/or regulatory infringements.</td>
<td>Operational</td>
<td>No robust historical analysis of flash flooding frequency currently available for the project area. Hence, information is insufficient to determine significant change to the baseline risk profile.</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
<td>Remain unaltered</td>
</tr>
<tr>
<td>Rehabilitation efforts may be hampered by an increase in the frequency and/or magnitude of heavy rainfall/flooding events (and also through slope failure).</td>
<td>Decommissioning</td>
<td>No robust historical analysis of flash flooding frequency currently available for the project area. Hence, information is insufficient to determine significant change to the baseline risk profile.</td>
<td>Direct</td>
<td>Medium-term</td>
<td>On-site</td>
<td>Somewhat altered</td>
</tr>
<tr>
<td>Impact description and consequence</td>
<td>Project Stage</td>
<td>Description of scenario and future impacts</td>
<td>Determining magnitude</td>
<td>Magnitude</td>
<td>Determining sensitivity/vulnerability</td>
<td>Sensitivity/vulnerability</td>
</tr>
<tr>
<td>----------------------------------</td>
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<td>---------------------------------------------</td>
<td>-----------------------</td>
<td>----------</td>
<td>-------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Strong wind may disrupt construction activity.</td>
<td>Construction</td>
<td>No robust historical analysis of global land surface winds or storminess currently available for the project area. Wind speeds within the project area are relatively low and information related to increase in wind gust speeds as a result of climate change is insufficient to determine significant change to the baseline risk profile.</td>
<td>Direct</td>
<td>Temporary</td>
<td>On-site</td>
<td>Remain unaltered</td>
</tr>
<tr>
<td>Strong winds could increase dust blown from pit or tailings operations, increase water use for dust suppression and impact nearby communities.</td>
<td>Operational</td>
<td>No robust historical analysis of global land surface winds or storminess currently available for the project area. Wind speeds within the project area are relatively low and information related to increase in wind gust speeds as a result of climate change is insufficient to determine significant change to the baseline risk profile.</td>
<td>Indirect</td>
<td>Temporary</td>
<td>Local</td>
<td>Remain unaltered</td>
</tr>
</tbody>
</table>
Table 2.10  **Assessment of Impacts where Mitigation Measures are in Place**

<table>
<thead>
<tr>
<th>Impact description and consequence</th>
<th>Relevant adaptation measures</th>
<th>Project Stage</th>
<th>Determining magnitude</th>
<th>Magnitude</th>
<th>Determining sensitivity/vulnerability</th>
<th>Sensitivity/vulnerability</th>
<th>Significance (magnitude x sensitivity/vulnerability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High temperatures may affect staff health (i.e. lead to heatstroke/dehydration) and may hamper productivity during the summer months.</td>
<td>• Adaptation measures are not available for this impact for the mine to implement, rather, such conditions may necessitate additional purchases of fuel to maintain the efficiency of certain types of equipment, for example.</td>
<td>Construction &amp; Operational</td>
<td>Direct</td>
<td>Long-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Small</td>
</tr>
<tr>
<td>High temperatures during summer may physically affect communities around the mine project site, leading to community unrest.</td>
<td>• Reduce, reuse and recycle water on site. • Install rainwater harvesting measures.</td>
<td>Construction &amp; Operational</td>
<td>Indirect</td>
<td>Long-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Small</td>
</tr>
<tr>
<td>High temperatures during summer may adversely affect access to water and any subsistence agriculture underway in the communities, leading to community unrest.</td>
<td>• Reduce, reuse and recycle water on site. • Install rainwater harvesting measures.</td>
<td>Construction &amp; Operational</td>
<td>Indirect</td>
<td>Long-term</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Small</td>
</tr>
<tr>
<td>High temperatures may reduce the efficiency of certain types of equipment utilised by the mine.</td>
<td>• Ensure regular maintenance of pump equipment • Erect flood protection measures around the pumps if necessary (raise the height at which the pumps sit,</td>
<td>Construction &amp; Operational</td>
<td>Direct</td>
<td>Temporary</td>
<td>On-site</td>
<td>Somewhat altered</td>
<td>Small</td>
</tr>
<tr>
<td>Impact description and consequence</td>
<td>Relevant adaptation measures</td>
<td>Project Stage</td>
<td>Determining magnitude</td>
<td>Determining sensitivity/ vulnerability</td>
<td>Sensitivity/ vulnerability</td>
<td>Significance (magnitude x sensitivity/ vulnerability)</td>
<td></td>
</tr>
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<td></td>
</tr>
</tbody>
</table>
| High temperatures coupled with low rainfall could compromise water availability within the region (ie by reducing the level of the Orange River and by the introduction of water restrictions). Such conditions would lead to reduced production. | • Install early warning systems so that the pumps can be protected effectively.  
• Design pumps to withstand more frequent flooding of the Orange River.  
• Install early warning systems.  
• Undertake research into appropriate flood control measures.  
• Implement appropriate flood control measures.  
• Undertake reinforced lining/protection of pits.  
• Install flood protection measures in and around the mine. | Operational | Indirect | Short-term | Local | Somewhat altered | Medium | 5-10 | Unlikely | Low | Minor |
| High temperatures result in high evaporation rates which result in the evaporation of fluids from the tailings facilities dams as well as vegetation loss. This will result in additional water being required for dust suppression, for example, and could result in salinisation of soils and result in non-compliance. | | | | | | | | | | | |

| |
| --- | --- | --- | --- | --- | --- | --- |
| Type | Duration | Extent | Scale | Frequency | Likelihood |
| Operational | Indirect | Short-term | Local | Somewhat altered | Medium | 5-10 | Unlikely | Low | Minor |
| Operational | Direct | Short-term | On-site | Remain unaltered | Small | >1 | Unlikely | Medium | Minor |

Environmental Resources Management  
Climate Change Impact Assessment for Gamsberg Zinc Mine  
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<table>
<thead>
<tr>
<th>Impact description and consequence</th>
<th>Relevant adaptation measures</th>
<th>Project Stage</th>
<th>Determining magnitude</th>
<th>Determining sensitivity/ vulnerability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooding of the lower reaches of the Orange River may damage the pumps on the River or result in them having to be pulled out of the river to avoid being damaged. Such conditions would lead to reduced production as a result of water abstraction capabilities being compromised.</td>
<td>• Vegetate slopes to prevent slope failure. • Implement structural measures to secure slopes (netting etc). • Undertake research into appropriate flood control measures. • Implement appropriate flood control measures. • Seek alternative access routes to utilise when normal routes are flooded.</td>
<td>Operational</td>
<td>Indirect</td>
<td>Short-term</td>
<td>On-site</td>
</tr>
<tr>
<td>Heavy rain leading to erosion and flooding in pit and surrounding area causing disruption to operations.</td>
<td>• Undertake reinforced lining/protection of waste rock area. • Install flood protection measures in and around the mine.</td>
<td>Operational</td>
<td>Direct</td>
<td>Short-term</td>
<td>On-site</td>
</tr>
<tr>
<td>Groundwater contamination from excess run off of water through pit and unauthorised discharge from storage facilities. This may result in reputational risks and/or regulatory infringements.</td>
<td>• Undertake reinforced lining/protection of tailings facility. • Install flood protection measures in and around the mine. • Undertake regular drain maintenance to reduce the flooding risks. • Monitor tailings dams to prevent over-flow during periods of high precipitation.</td>
<td>Operational</td>
<td>Direct</td>
<td>Short-term</td>
<td>Local</td>
</tr>
<tr>
<td>Impact description and consequence</td>
<td>Relevant adaptation measures</td>
<td>Project Stage</td>
<td>Determining magnitude</td>
<td>Determining sensitivity/ vulnerability</td>
<td>Significance (magnitude x sensitivity/ vulnerability)</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------------</td>
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<td>-----------------------</td>
<td>---------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
</tbody>
</table>
| Flash flooding may prevent access to and from the mine, thereby preventing the transport of product and staff. | • Implement flood control measures  
• Implement structural measures to secure slopes (netting etc). | Operational | Direct | Short-term | Local | Somewhat altered | Small | 1-5 | Unlikely | Medium | Minor |
| Heavy rain will increase the quantity of water draining through waste rock pile leading to unauthorised discharge. This may result in reputational risks and/or regulatory infringements. | • Adaptation measures are not available for this impact for the mine to implement. | Operational | Direct | Short-term | Local | Unaltered | Small | 1-5 | Unlikely | Low | Negligible |
| Failure of tailings storage as a result of flooding. This may result in reputational risks and/or regulatory infringements. | • Reduce, reuse and recycle water on site  
• Install rainwater harvesting measures to ensure that water is available on site for dust suppression. | Operational | Direct | Short-term | Local | Unaltered | Small | 1-5 | Unlikely | Low | Negligible |
<p>| Rehabilitation efforts may be hampered by an increase in the frequency and/or magnitude of heavy rainfall/flooding events (and also through slope failure). | • Rehabilitation efforts may be hampered by an increase in the frequency and/or magnitude of heavy rainfall/flooding events (and also through slope failure). | Operational | Direct | Medium-term | On-site | Somewhat altered | Medium | 1-5 | Unlikely | Low | Minor |
| Strong wind may disrupt construction activity. | Strong wind may disrupt construction activity. | Operational | Direct | Temporary | On-site | Unaltered | Negligible | &gt;1 | Unlikely | Medium | Negligible |</p>
<table>
<thead>
<tr>
<th>Impact description and consequence</th>
<th>Relevant adaptation measures</th>
<th>Project Stage</th>
<th>Determining magnitude</th>
<th>Magnitude</th>
<th>Determining sensitivity/vulnerability</th>
<th>Sensitivity/vulnerability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong winds could increase dust blown from pit or tailings operations, increase water use for dust suppression and impact nearby communities.</td>
<td>Strong winds could increase dust blown from pit or tailings operations, increase water use for dust suppression and impact nearby communities.</td>
<td>Operational</td>
<td>Indirect</td>
<td>Temporary</td>
<td>Local</td>
<td>Remain unaltered</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

*Environmental Resources Management Climate Change Impact Assessment for Gamsberg Zinc Mine*
2.8 **CRA STEP 5: RISK MITIGATION**

In the climate change context, mitigation of risks associated with the physical impacts of climate change is referred to as ‘adaptation’. *Climate Adaptation* in the context of capital project development can be thought of as activities to avoid, minimise or mitigate the business risks arising from extreme weather events and/or gradual changes in climate. Adaptation measures include altering physical design of the mine site or infrastructure, implementing business procedures, and altering operating patterns.

Successful adaptation will encompass a variety of physical, operational, management or strategic measures and will include a strong on-going review element to re-visit and confirm the climate science projections and assumptions that underlie the original risk assessment.

*Figure 2.21* provides an overview of different approaches to adaptation. At a facility (mine site) level, climate adaptation measures could include:

- **‘Hard’ adaptation measures** that are incorporated into the design. For example, where flooding is a key risk for an area, an operation may adapt by building flood defences to protect flood-prone areas. Alternatively, where increasingly intense storms pose a risk to power transmission lines, undergrounding exposed portions of the line may significantly reduce the risk of interruption.

- **‘Soft’ adaptation measures** are incorporated into operational procedures or processes. For example, where increased risk of extreme high temperatures and heat wave events is identified at a site, procedural health and safety measures could be implemented that address this particular risk, eg changing shift patterns to avoid employees or contractors working during the hottest part of the day.
Table 2.11 outlines a selection of potential adaptation measures which could be implemented on site. Gamsberg engineers should consider the potential impact of weather events on the project during the design process.
Table 2.10 highlights how the significance of the weather-related impact changes if/once mitigation measures to minimise/mitigate the risk are implemented.
<table>
<thead>
<tr>
<th>Climate Variable/Event</th>
<th>Potential Impact on Mining and Associated Activities</th>
<th>Phase of Mine Affected</th>
<th>Project Component Impacted</th>
<th>Possible Adaptation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in disease distribution.</td>
<td>Increased incidence of dengue, carrier's disease, diarrhoea, bartonellosis, malaria and other vector-borne diseases (given increase flooding and/or higher temperatures) will impact the health of the workforce and surrounding community putting a strain on health facilities.</td>
<td>• Construction.</td>
<td>Health.</td>
<td>• Roll out community health programmes as part of community-based adaptation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Operations.</td>
<td></td>
<td>• Establish a health support programme for staff, including training on the avoidance of disease and infection as well the distribution of prevention materials (such as mosquito nets, malaria prophylaxis etc).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Closure/ rehabilitation.</td>
<td></td>
<td>• Clear unwanted water bodies (eg small puddles) to prevent them acting as mosquito breeding grounds.</td>
</tr>
<tr>
<td>Cyclones/high winds.</td>
<td>Strong winds could increase dust blown from pit or tailings operations and affect local communities.</td>
<td>• Operations.</td>
<td>Community support.</td>
<td>• Improve dust suppression mechanisms under high wind conditions.</td>
</tr>
<tr>
<td>Drought.</td>
<td>Drought may threaten the security of water supply and/or result in reduced abstraction levels from neighbouring rivers leading to reduced production.</td>
<td>• Operations.</td>
<td>Water supply.</td>
<td>• Install rainwater harvesting measures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Introduce water recycling.</td>
</tr>
<tr>
<td>Human adaptation/migration and increased competition for land.</td>
<td>Changes in climate impacting agriculture and food security could lead to conflict within local communities.</td>
<td>• Construction.</td>
<td>Community support.</td>
<td>• Roll out community-based adaptation programmes considering improving food security under climate change conditions (including the introduction of drought-adapted farming techniques and materials) to improve the resilience of the community.</td>
</tr>
<tr>
<td>Lightning storms.</td>
<td>Heavy lightning storms may result in injuries to staff at the mine.</td>
<td>• Construction.</td>
<td>Safety.</td>
<td>• Install early warning systems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Operations.</td>
<td></td>
<td>• Install lightning protection measures (rods etc).</td>
</tr>
<tr>
<td>Climate Variable/Event</td>
<td>Potential Impact on Mining and Associated Activities</td>
<td>Phase of Mine Affected</td>
<td>Project Component Impacted</td>
<td>Possible Adaptation Measures</td>
</tr>
<tr>
<td>------------------------</td>
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<td>------------------------</td>
<td>---------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Lightning storms.</td>
<td>Lightning could trip power supply causing interruption to construction activities.</td>
<td>• Construction. • Operations.</td>
<td>Energy/power supply.</td>
<td>• Investigate the installation of a backup source of electricity for use under such conditions. • Install lightning protection measures (rods etc).</td>
</tr>
<tr>
<td>Lightning storms.</td>
<td>Lightning could trip electronics (including, for example, weighbridges) resulting in business interruption or downtime.</td>
<td>• Operations.</td>
<td>Mine infrastructure and facilities.</td>
<td>• Install early warning systems. • Install lightning protection measures (rods etc).</td>
</tr>
<tr>
<td>Pluvial/fluvial flooding.</td>
<td>Delays to construction due to heavy precipitation and/or flooding.</td>
<td>• Construction.</td>
<td>Mine infrastructure and facilities.</td>
<td>• Install early warning systems. • Undertake research into appropriate flood control measures. • Implement appropriate flood control measures. • Undertake regular drain maintenance to reduce the flooding risks. • Monitor process/effluent water etc ponds to prevent over-flow during periods of high precipitation. • Implement appropriate flood control measures.</td>
</tr>
<tr>
<td>Pluvial/fluvial flooding.</td>
<td>Increased flooding may result in damage to the water abstraction pumps in the Orange River cutting off the only fresh water source.</td>
<td>• Construction. • Operations.</td>
<td>Water supply.</td>
<td>• Install early warning systems so that the pumps can be protected effectively. • Design pumps to withstand more frequent flooding of the Orange River.</td>
</tr>
<tr>
<td>Pluvial/fluvial flooding.</td>
<td>Disrupted access to facilities due to flooding/ landslides/ erosion leading to interruption to supply of inputs such as diesel/materials.</td>
<td>• Operations.</td>
<td>Supply chain.</td>
<td>• Vegetate slopes to prevent slope failure. • Implement structural measures to secure slopes (netting etc). • Undertake research into appropriate flood control measures. • Implement appropriate flood control measures.</td>
</tr>
<tr>
<td>Climate Variable/Event</td>
<td>Potential Impact on Mining and Associated Activities</td>
<td>Phase of Mine Affected</td>
<td>Project Component Impacted</td>
<td>Possible Adaptation Measures</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------------------------</td>
<td>-------------------------</td>
<td>---------------------------</td>
<td>-----------------------------</td>
</tr>
</tbody>
</table>
| Pluvial/fluvial flooding. | Flooding might cause non-compliance with permit requirements (e.g., by causing an overflow of contaminated water into the environment). | • Operations. | License to operate. | • Undertake research into appropriate flood control measures.  
• Implement appropriate flood control measures.  
• Monitor dams to prevent over-flow during periods of high precipitation. |
| Pluvial/fluvial flooding. | Groundwater contamination from excess run-off of water through pit and unauthorised discharge from storage facilities. | • Operations. | Mine infrastructure and facilities. | • Undertake reinforced lining/protection of pits.  
• Install flood protection measures in and around the mine. |
| Pluvial/fluvial flooding. | Failure of tailings storage resulting in seepage into groundwater system. Also, heavy rain leading to excessive water and pressure on tailings dam leading to overflow/failure and impacts on downstream communities. | • Operations  
• Closure. | Tailings Facility. | • Undertake reinforced lining/protection of tailings facility.  
• Install flood protection measures in and around the mine.  
• Undertake regular drain maintenance to reduce the flooding risks.  
• Monitor tailings dams to prevent over-flow during periods of high precipitation. |
| Precipitation. | A reduction in precipitation will adversely affect process water supply as well as water availability for dust suppression etc. | • Operations. | Water supply. | • Install rainwater harvesting measures.  
• Introduce water recycling. |
| Drought. | Unsuccessful rehabilitation planting due to drought events. | • Closure/  
• Rehabilitation. | Rehabilitation. | • Select plant species (naturally occurring in the area) with deep-root systems that are more likely to withstand episodes of heavy precipitation/flooding.  
• Undertake planting during the dry months.  
• Vegetate slopes to prevent slope failure.  
• Implement structural measures to secure slopes (netting etc.). |
<table>
<thead>
<tr>
<th>Climate Variable/Event</th>
<th>Potential Impact on Mining and Associated Activities</th>
<th>Phase of Mine Affected</th>
<th>Project Component Impacted</th>
<th>Possible Adaptation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation/storm events.</td>
<td>Episodes of heavy precipitation may result in the slipping of product on conveyors or damage to conveyors (if applicable).</td>
<td>• Operations.</td>
<td>Mine infrastructure and facilities.</td>
<td>• Use alternative methods of transporting product during rainstorms.</td>
</tr>
<tr>
<td>Precipitation/storm events.</td>
<td>High precipitation may result in the pollution of the environment by the mine’s waste products. This may result in fines and/or other regulatory issues.</td>
<td>• Operations.</td>
<td>Regulatory consent.</td>
<td>• Install flood protection measures around areas harbouring waste materials, in particular.</td>
</tr>
<tr>
<td>Storm events.</td>
<td>Increased delays to construction activities as well as increased maintenance costs and possible business delays during operations.</td>
<td>• Construction. • Operations.</td>
<td>Mine infrastructure and facilities.</td>
<td>• Undertake more regular maintenance of infrastructure given an increase in heavy precipitation and storm events. • Implement flood control measures to reduce/prevent impact to infrastructure.</td>
</tr>
<tr>
<td>Drought.</td>
<td>Reduced process water availability due to increased evapotranspiration (in particular when coupled with reduced precipitation). Higher temperatures, coupled with lower precipitation, may also see the introduction of water restrictions which will adversely affect the mine.</td>
<td>• Operations.</td>
<td>Water supply.</td>
<td>• Install rainwater harvesting measures. • Introduce water recycling.</td>
</tr>
<tr>
<td>Temperature.</td>
<td>Consequent reduction in soil moisture results in increased dust levels which becomes increasingly difficult to manage given the reduced water availability.</td>
<td>• Construction. • Operations.</td>
<td>Air quality controls.</td>
<td>• Install rainwater harvesting measures. • Introduce water recycling. • Investigate alternative dust management/suppression options (ie not involving the use of water).</td>
</tr>
<tr>
<td>Climate Variable/Event</td>
<td>Potential Impact on Mining and Associated Activities</td>
<td>Phase of Mine Affected</td>
<td>Project Component Impacted</td>
<td>Possible Adaptation Measures</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------------------------</td>
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<td>----------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Temperature.</td>
<td>Colder temperatures may result in an inversion layer making it more difficult to disperse air pollution, resulting in community complaints.</td>
<td>• Construction. • Operations.</td>
<td>Air quality controls.</td>
<td>• Engage with communities on the pollution issues to come up with creative solutions. • Conduct study into how to avoid such a situation.</td>
</tr>
<tr>
<td>Temperature.</td>
<td>Mine staff may experience health impacts as a result of high temperatures, e.g. heat stress, which may result in delays.</td>
<td>• Construction. • Operations.</td>
<td>Health.</td>
<td>• Prevent working under very hot conditions. • Ensure availability of cool drinking water for staff on-site. • Change working hours to prevent working at the heat of the day.</td>
</tr>
<tr>
<td>Temperature.</td>
<td>Reduced efficiency of equipment due to hotter temperature resulting in increased operational costs (higher temperatures lead to trips).</td>
<td>• Operations.</td>
<td>Mine infrastructure and facilities.</td>
<td>• Review and adjust, if possible, the operating temperature for equipment. • Increase maintenance schedule to prevent slow/shut downs. • Install a winterisation programme.</td>
</tr>
<tr>
<td>Wildfires.</td>
<td>Increased maintenance costs as a result of increased fire damage.</td>
<td>• Operations.</td>
<td>Mine infrastructure and facilities.</td>
<td>• Construct adequate firebreaks around the facilities.</td>
</tr>
</tbody>
</table>
3.1 APPROACH AND METHODOLOGY

3.1.1 Introduction

This study has been undertaken in accordance with international best practice emissions estimation techniques and ERM’s impact assessment approach as outlined in the Gamsberg ESIA Report. This section provides an overview of the methodology for calculating the carbon footprint and provides comment on how the impact assessment has been approached.

The study has involved a desktop assessment of international and national climate change literature; review of relevant Gamsberg documentation and discussions with Gamsberg representatives and specialist studies consultants. No field work was undertaken for the scope of work undertaken in this report.

3.1.2 Carbon Footprint Calculation

Methodology

A carbon footprint is a measure of the estimated greenhouse gas emissions caused directly and indirectly by an individual, organisation, event or product. The calculation of a carbon footprint generally involves the following equation:

\[ \text{Carbon footprint emissions} = \text{activity data} \times \text{emissions factor} \times \text{global warming potential} \]

- \textit{Activity data} relates to the emission causing activity eg the combustion of a quantity of diesel or the use of a quantity of refrigerant gases;

- \textit{Emission factors} convert the activity data collected and consolidated into tonnes of the relevant greenhouse gas; and

- \textit{Global warming potentials} are applied to non-CO\textsubscript{2} GHG to convert the result to carbon dioxide equivalent (tCO\textsubscript{2}e).

The Gamsberg carbon footprint has been estimated in accordance with the GHG Protocol: Corporate Accounting & Reporting Standard developed by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI). The GHG Protocol provides comprehensive guidance on accounting and reporting corporate GHG emissions. It is the most widely used standard for mandatory and voluntary GHG programmes and makes use of the Intergovernmental Panel on Climate Change (IPCC) GHG Inventory guidelines for specific heating values, carbon content, densities and emission factors. Where applicable, ERM has referred to Gamsberg specific data and the following sources for country and process specific factors:

- IPIECA Petroleum industry guidelines for reporting greenhouse gas emissions;
• Intergovernmental Panel on Climate Change (IPCC) 2006 GHG Inventory guidelines;

• Department for Environment, Food and Rural Affairs (Defra) 2012 GHG Conversion Factors for Company Reporting Guidelines; and


The calculation using these standards ensures that the Gamsberg Carbon Footprint is aligned with international standards.

**Emissions Boundary Definition**

The scope of the carbon footprint depends on definition of two boundaries relating to the organisational and operational aspects of the project as outlined below. The boundaries drawn for the purposes of this project are discussed further in Section 3.2.

*Organisational boundaries* determine whether reporting is done according to the “equity share approach” (different economic interest is reflected by companies being wholly owned, incorporated or non-incorporated join ventures or subsidiaries) or the “control approach” (emissions accounted for from operations under the direct operational control of the parent company).

*Operating boundaries* determine which emission causing activities will be included in the carbon footprint. The GHG Protocol divides emissions into three categories as described below and illustrated in *Figure 3.1*:

- **Scope 1** – *direct emissions* from sources owned or under the operational control of the company;

- **Scope 2** – *indirect emissions* from the consumption of purchased electricity; and

- **Scope 3** – *indirect emissions* an optional reporting category allowing for other indirect emissions associated but not controlled by the company to be included such as contractor activities.
3.1.3 **Impact Assessment Methodology**

A traditional impact assessment is conducted by determining how the proposed activities will affect the state of the environment prior to development of a project (as discussed in the *Gamsberg ESIA Report*). In the case of GHG emissions, this process is complicated by the fact that the impact of GHG emissions on the environment cannot be quantified within a defined space and time.

The greenhouse effect occurs on a global basis and the point source of emissions is irrelevant when considering the future impact on the climate. It is not possible to link emissions from a single source – such as the Gamsberg Zinc Mine facility - to particular impacts in the broader study area.

Subsequently, this specialist study does not consider the physical impacts of climate change resulting from increasing GHG emissions, but rather the impact of the project on South Africa’s National GHG Inventory and the implications of this.

When assessing the impact of the estimated Gamsberg operational emissions against South Africa’s national GHG inventory, two scenarios are presented.

1. comparison with the most recent and published national GHG inventory for South Africa, namely 2000 (which is the third national inventory to have been developed for South Africa and has been developed using the 2006 IPCC Guidelines); and

2. comparison with an emissions trajectory from 2000 to 2035 which has been determined based on historic and projected economic growth and development pathways.
3.2 **SCOPE OF THE CARBON FOOTPRINT**

3.2.1 **Introduction**

This section defines the scope of the Gamsberg carbon footprint in terms of emission boundaries, timing of emission causing activities, and an overview of emission causing activities. The results of the carbon footprint calculation are presented in Section 3.4.

3.2.2 **Organisational and Operational Boundary**

The organisational boundary has been defined according to the control approach where emissions from sources under the direct operational control of Gamsberg will be included in the carbon footprint as illustrated in *Error! Reference source not found.*

Figure 3.2 *Gamsberg Carbon Footprint Boundary*

![Gamsberg Carbon Footprint Boundary Diagram]

It is assumed that Gamsberg will pay for the fuel used by contractors on site and therefore the emissions associated with their activities have been included under Scope 1. All electricity to be purchased is included under Scope 2 emissions.

Scope 3 (indirect) emissions would typically be from outsourced activities, such as contractor activity and employee business travel. These emissions have been excluded for the purposes of this study due to the fact that there is considerable uncertainty with respect to estimating contractor activity and employee business travel. Scope 3 emissions associated with export of Zinc have not been included in the overall carbon footprint as discussed in Section 3.4.
3.2.3 Timeframe

Construction is due to begin in 2013 and will continue until 2017. With operations beginning during Quarter 2 of 2015, the life of the facility is anticipated to be 20 years, indicating closure in 2035. The production capacity of the Gamsberg Zinc mine is 10 million tonnes of zinc ore per year. Table 3.1 shows the timing from the construction phase to decommissioning.

The project programme, based on the current work schedule, is summarised below.

Table 3.1 Timeframe from Construction to Full Operations of Gamsberg

<table>
<thead>
<tr>
<th>Phase</th>
<th>Commencement</th>
<th>Completion</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>2013 – Q4</td>
<td>2017 – Q1</td>
<td>42 months</td>
</tr>
<tr>
<td>Operations</td>
<td>2015 – Q2</td>
<td>2035</td>
<td>20 Years</td>
</tr>
<tr>
<td>Decommissioning</td>
<td>2036</td>
<td>tbc</td>
<td>tbc</td>
</tr>
</tbody>
</table>

3.2.4 Overview of Gamsberg Emission Causing Activities

The proposed Gamsberg zinc mine is located between the existing town of Aggeneys and the town of Pofadder, approximately 120 km east of the Springbok, along the N14. The proposed site is characterised by an oval shaped inselberg approximately 220 meters above the surrounding plains. The existing gravel road from Gamsberg to the Sishen-Saldanha railway line, at Loop 10 railway siding, is located approximately 160 km east of the Gamsberg mine. The Project Description in the Gamsberg ESIA Report provides a detailed account of the activities associated with the proposed project.

Table 3.2 summarises the key emission sources occurring on site and indicates those which are included in the carbon footprint.

Table 3.2 Summary of Key Emission Sources

<table>
<thead>
<tr>
<th>Emission Scope</th>
<th>Emission Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile combustion.</td>
<td>Fuel used in terrestrial vehicles including cars, buses etc. Fuel used in mobile equipment.</td>
</tr>
<tr>
<td>Stationary combustion.</td>
<td>Diesel used for power generation such as generators. Diesel used for stationary equipment.</td>
</tr>
<tr>
<td>Non-Combustion.</td>
<td>Lubricants - Use of lubricant oils and greases in machinery.</td>
</tr>
<tr>
<td>Refrigerants.</td>
<td>Leakage/use of refrigerant gases in air conditioning units in vehicles and offices/accommodation in air conditioning units.</td>
</tr>
<tr>
<td>Explosives.</td>
<td>Explosives used in the blasting of rock in the core activity of the open cast mining activity of this operation.</td>
</tr>
<tr>
<td>Emission Scope</td>
<td>Emission Source</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Waste emissions.</td>
<td>Methane emissions from waste.</td>
</tr>
<tr>
<td></td>
<td>Methane emissions from waste water (sewage) treatment.</td>
</tr>
<tr>
<td>Electricity.</td>
<td>Emissions associated with the total electricity consumed.</td>
</tr>
</tbody>
</table>

3.2.5 Assumptions made in Estimating Operational Activity Data

Good practice for calculating a carbon footprint dictates that actual activity data (e.g., litres of diesel consumed) for a financial year is used. Given that this project involves an estimation of a future carbon footprint for activities yet to begin, a series of assumptions have been made in order to obtain the activity data required to undertake this calculation.

Data was obtained from the ESIA Report, the finding presented by specialists at the Specialist Study Workshop held in January 2013, and through data provided by Gamsberg personnel. The carbon footprint has been estimated in accordance with current design options and the information presented in the ESIA Report. Appendix B provides a detailed account of the assumptions that have been made in relation to each aspect of the carbon footprint calculation.

The carbon footprint includes estimated direct emissions from activities associated with the operation of the facilities. Embedded emissions associated with the materials used are regarded as Scope 3 and not included as they are outside the scope of this project.
3.3 GHG EMISSIONS IN SOUTH AFRICA AND FROM GAMSBERG

3.3.1 GHG Emissions in South Africa

This section presents a description of South Africa’s National Greenhouse Gas Inventory, or carbon footprint. This information is sourced from 2000 National GHG Inventory Report, published by the Department of Environmental Affairs and Tourism in May 2009. The 2000 National GHG Inventory is presented in relation to the 1990 and 1994 national inventories.

South Africa’s first national inventory was published in 1998 using 1990 data. The second national inventory was published in 2004, using 1994 data. The 1990 and 1994 inventories were developed using the 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National GHG Inventories. The 2000 GHG Inventory, published in 2009, is the third national inventory to have been developed for South Africa and has been developed using the 2006 IPCC Guidelines.

The total emissions for the 2000 GHG inventory were 461.2 million tonnes CO$_2$e (MtCO$_2$e). 83% of emissions were associated with energy supply and consumption with smaller contributions from industrial processes (7%), agriculture (8%) and waste (2%) (Table 3.3.1). These figures exclude emissions or sinks from land use, land use change and forestry (LULUCF). These LULUCF activities provide a net sink of 18.694 MtCO$_2$e and result in the total emissions for the 2000 inventory including LULUCF being 442.287 MtCO$_2$e.

<table>
<thead>
<tr>
<th>Sector</th>
<th>GHG emissions - 2000 (MtCO$_2$e)</th>
<th>% of total</th>
<th>% change from 1994</th>
<th>% change from 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>380.998</td>
<td>83%</td>
<td>82%</td>
<td>46%</td>
</tr>
<tr>
<td>Industrial Processes &amp;</td>
<td>32.081</td>
<td>7%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>Product Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>20.022</td>
<td>8%</td>
<td>9%</td>
<td>-4%</td>
</tr>
<tr>
<td>Waste</td>
<td>9.393</td>
<td>2%</td>
<td>-43%</td>
<td>-38%</td>
</tr>
<tr>
<td><strong>Total (without LULUCF)</strong></td>
<td><strong>461.178</strong></td>
<td><strong>100%</strong></td>
<td><strong>21%</strong></td>
<td><strong>33%</strong></td>
</tr>
</tbody>
</table>

Source: Second National Communication

In the absence of actual emissions data, GDP growth has been used as a proxy for emissions growth from 2000 to present. Appendix BError! Reference source not found. illustrates the variation in South Africa’s growth rate from 2000 – 2011, with the average of 2000 to 2011 being utilised to project GDP growth for 2012 – 2035.
South Africa has shown a volatile growth rate between 2000 and 2011. The average over these eleven years (ie 2000 to 2011) of 3.6% per annum has been used to project emissions from 2012 – 2035. The extent of the increase in national emissions is somewhat dependent on the policy, legislative framework, the type of development (eg manufacturing, mining, oil and gas) and GDP growth in South Africa, and the timing thereof. It is, however, the best estimate of potential future emissions in the country. Figure 3.4 illustrates South Africa’s estimated historic and projected national emissions based on a 2000 baseline and past and predicted GDP growth.
3.4 ESTIMATED GHG EMISSIONS FROM GAMSBERG FACILITY

3.4.1 Overview

The operational carbon footprint for the Gamsberg is estimated to be approximately 552 449 tCO$_2$e per annum from 2015 onwards. The carbon footprint presents forecast estimates for Scope 1 emissions, and estimated emissions from electricity (Scope 2). Scope 3 emissions have been excluded from the study due to the fact that there is considerable uncertainty with respect to estimating contractor activity and employee business travel.

*Error! Reference source not found.* breaks down emissions for each source during a year of ‘normal’ operations once construction has ended. It should be noted that this does not include additional activities which may come into play in future.

Table 3.4 Gamsberg Estimated Annual Operational Carbon Footprint

<table>
<thead>
<tr>
<th>Emission Source</th>
<th>Estimated Operational Emissions (tCO$_2$e)</th>
<th>Percentage of total emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Combustion</td>
<td>44 246</td>
<td>8.01%</td>
</tr>
<tr>
<td>Stationary Combustion</td>
<td>1 630</td>
<td>0.3%</td>
</tr>
<tr>
<td>Non Combustion</td>
<td>178</td>
<td>0.0%</td>
</tr>
<tr>
<td>Refrigerant Usage</td>
<td>1 170</td>
<td>0.2%</td>
</tr>
<tr>
<td>Explosives</td>
<td>362</td>
<td>0.1%</td>
</tr>
<tr>
<td>Waste</td>
<td>7 883</td>
<td>1.4%</td>
</tr>
<tr>
<td>Electricity</td>
<td>496 980</td>
<td>90.0%</td>
</tr>
<tr>
<td><strong>Total CO$_2$e Emissions</strong></td>
<td><strong>552 449</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

*Error! Reference source not found.* provides a breakdown of estimated emissions associated with the Gamsberg facilities. Emissions related to Scope 2 activities (ie electricity usage) account for 496 980 tCO$_2$e, which is 90% of the total emissions. Scope 1 emissions will account for 55 469 tCO$_2$e, which is 10% of the total emissions. *Error! Reference source not found.* illustrates the emissions associated with Scope 1 activities.
The emissions associated with Gamsberg facilities can be estimated as follows:

- The electricity required to run mining operations is estimated to be 490 million kWh per annum, and the electricity required to run the staff housing is estimated to be 12 million kWh per annum. The total emissions from the electricity is estimated to be 496 980 tCO\textsubscript{2}e, which represents 90% of the overall emissions.

- Mobile combustion emissions result from transport related activities. Zinc Ore will be transported by truck to Loop 10, and then railed to the Port of Saldanha for distribution. The trains, and other distribution avenues, will be operated by a third party, which is not part of the scope of this study. Therefore the emissions included in this study are emissions associated with the terrestrial mining fleet at the Gamsberg facilities. The total emissions from mobile combustion (ie emissions from transport related activities) are estimated to be 44 246 tCO\textsubscript{2}e, which represents 8% of the overall emissions.

- The total emissions from non-combustion activities, ie lubricants and oils, utilised during the mining process are estimated to be 178 tCO\textsubscript{2}e, which is less than 1% of the overall emissions.

- It is assumed that all refrigerants would be filled using the standard HFC-134A refrigerant which has a GWP of 1430. The total emissions from refrigerants usage is estimated to be 1170 tCO\textsubscript{2}e, which is less than 1% of the overall emissions.

- Explosives will be used for blasting activities during the operational activities, and accounts for an estimated 362 tCO\textsubscript{2}e, which is less than 1% of the overall emissions.

- Methane emissions which are generated by the waste disposal will be minimal, but will mainly arise from waste collection and storage, and the waste water treatment facilities. This is due to the fact that waste will be
collected and disposed at the existing sewerage plant at Aggeneys. Methane emissions generated by the waste water (sewerage) treatment facility and will account for 3 450 tCO$_2$e, which represents less than 1% of the overall emissions, and emissions from the waste collection and will account for 4 433 tCO$_2$e, which represents less than 1% of the overall emissions. Total emissions associated with waste related activities will account for 7 883 tCO$_2$e, which represents 1.4% of the overall emissions.

Error! Reference source not found. illustrates the breakdown of waste emissions from different waste related activities at Gamsberg.

Figure 3.6 Breakdown of Gamsberg Waste Emissions by Year

Gamsberg personnel provided ERM with consumption estimates for the various activities at Gamsberg. ERM was not able to obtain the background data used in the calculation and was therefore not able to verify the calculation. However, it is assumed that the estimates are based on the design parameters, the equipment to be employed and the comparison between similar activities.

3.4.2 Carbon Tax Exposure

South Africa’s National Treasury has proposed a carbon tax pricing framework. Phase 1 of the framework will be implemented until 2020, after which a new carbon tax pricing framework will be introduced. The proposed carbon tax is explained in detail in Section 3.5.5, which provides illustrations on the proposed carbon tax pricing framework, and the different variables that can decrease or increase your tax-free threshold depending on characteristics of the sector, processes involved and carbon emissions.

All industries will receive a 60% tax free threshold in the initial phase of the tax for the period until 2020. Depending on the industry categorisation (due to exposed to international trade and/or if some of its fossil fuel results in process emissions), a further 5% to 10% rebate on the total taxable emissions, resulting in a rebate of 80%. An installation can further reduce its carbon tax exposure by
5% to 10% if it utilises carbon credits as offsets against the carbon tax. The total carbon tax rebate cannot exceed 90%.

According to the proposed carbon tax pricing framework, various carbon tax exposure scenarios are possible for the Gamsberg Zinc Mine as shown in Table 3.4.2.

<table>
<thead>
<tr>
<th>Rebate</th>
<th>Tax Rate per tonne</th>
<th>Estimated Annual Emissions</th>
<th>Taxable Emissions</th>
<th>Annual Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td>R 120</td>
<td>552 449</td>
<td>220 980</td>
<td>R 26 517 552</td>
</tr>
<tr>
<td>80%</td>
<td>R 120</td>
<td>552 449</td>
<td>110 490</td>
<td>R 13 258 776</td>
</tr>
<tr>
<td>90%</td>
<td>R 120</td>
<td>552 449</td>
<td>55 245</td>
<td>R 6 629 388</td>
</tr>
</tbody>
</table>

According to the proposed carbon tax pricing framework (as explained in detail in Section 3.5.5), the carbon tax rebate will fall between 60% and 80% during Phase 1 (ie until 2020). This will result in an annual carbon tax exposure between R 13 258 776 and R 26 517 552 for the Gamsberg mine facility. However, it is possible for the Gamsberg facility to utilise carbon offsets to reduce carbon tax exposure. This could reduce the annual tax exposure to a minimum of R 6 629 388. As previously stated, these estimates are only valid until 2020.

Although the implementation date, and the framework of the carbon tax has not been finalised, it is likely into come into effect within the next one to three years. More concrete indication of Government’s intentions in relation to carbon pricing is presented in the National Climate Change Response White Paper.

3.4.3 Uncertainty and Gaps

The significant direct emission sources have been included in the estimated carbon footprint of operations of the Gamsberg facilities. There is a significant level of uncertainty in the estimates given the early stage of project design. This report is based on the designs and assumptions available at the time of writing and the results may or may not correlate to the final design of the facility. Broad assumptions have been made in calculating emissions as outlined in Appendix B.
3.5 IDENTIFICATION OF APPLICABLE POLICIES, LEGISLATION, STANDARDS AND GUIDELINES

3.5.1 Introduction

The Department of Environmental Affairs (DEA) is the designated lead department responsible for co-ordination and implementation of South Africa’s commitments and related matters in terms of the UNFCCC. South Africa does not currently regularly report emissions of national greenhouse gas emissions. However, the International Finance Corporation (IFC) requires that facilities with emissions over 25,000tCO$_2$e per year monitor and report emissions on an annual basis, and that steps should be taken to reduce emissions and enhance resource efficiency of all activities.

This section looks at national and international climate change frameworks and South Africa’s commitments under these, as well as the requirements of the IFC in relation to GHG emissions.

3.5.2 International Climate Change Frameworks and Mechanisms

The UNFCCC, Kyoto Protocol and Doha Climate Gateway

The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 with the aim of stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

In 1997, the Kyoto Protocol (an ‘update’ to the UNFCCC) was signed, setting binding limits on the amount of greenhouse gas emissions allowed in ‘developed countries’ over the period 2008 – 2012. It divides the world into Annex I ‘developed’ countries which have a greenhouse gas target and all other countries ‘non-Annex I’ which do not have targets. The Kyoto Protocol came into force on 16 February 2005 following ratification by Russia, bringing the global emissions covered by the 177 signatories to over 50%. The USA, China and Canada (who withdrew in 2011) are the only major emitters not to have ratified the protocol.

The Doha Climate Change Conference, the 18th Conference of Parties (COP 18) of the UN Framework Convention on Climate Change, held at the end of 2012 resulted in the “Doha Climate Gateway” decisions. The main outcomes were:

- A second commitment period for the Kyoto Protocol. However, fewer countries are participating, and they have only agreed to reduce their overall emissions by at least 18% below 1990 levels in the eight year period (2013-2020). Participating countries represent less than 15% of global greenhouse gas emissions, and the emissions reduction commitments are insufficient to keep global warming below the 2°C limit;
• Agreement to consider the creation of an international mechanism for loss and damage from extreme weather and slow onset climate impacts in developing countries;

• The need for a plan for long-term finance was reiterated. However, no firm commitments on scaling up finance towards the agreed US$ 100 billion a year were forthcoming. Climate finance pledges amounting to approximately US$ 10 billion were made by some European countries; and

• Developed countries were urged to increase the ambition of their emission reduction targets and a work programme will be established to clarify pledges.

While there are currently no legally-binding emissions reductions targets in several developed countries (including the USA), those countries are increasingly applying political pressure through other institutions such as the World Bank, in order to encourage climate change mitigation in the developing economies.

**Market Mechanisms to promote emission reductions**

The Kyoto Protocol created market mechanisms to help finance emissions reduction projects - creating a carbon market. Participation in Emissions Trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI) allow Annex 1 countries to meet the GHG emission limitations by purchasing GHG emission reduction credits from projects that reduce emissions in non-Annex 1 countries (CDM), or from other Annex 1 countries through JI or emissions trading.

Japan have withdrawn from the continuation of the Kyoto protocol, and have proposed their own scheme, the Bilateral Offset Crediting Mechanism (BOCM). Japan’s BOCM is similar to the CDM in that a funding country (Japan) invests in emissions reduction projects or programs in developing countries and gains offsets credits. The key difference lies in a simplified procedure which stays mostly at the bilateral level whereas the CDM is administered by the international body UNFCCC. International oversight under the BOCM is minimised to the function of providing guidance for emissions monitoring, reporting and verification (MRV) and accounting rules only. Despite potential benefits, issues relating to the accounting rules, environmental integrity and implications to carbon markets warrant further consideration prior to international recognition.

### 3.5.3 South Africa’s Climate Change Commitments and Governance

Following the 2009 UNFCCC Climate Change Conference in Copenhagen (COP15), countries (both developed and developing) were requested to show their support for the ‘Copenhagen Accord’ and outline emission reduction commitments and nationally appropriate mitigation actions which they would undertake in order to play their part in efforts to reduce GHG emissions.
As the designated lead department responsible for co-ordination and implementation of South Africa’s commitments and related matters in terms of the UNFCCC, the DEA is supported by two committees is aimed at operationalising cooperative governance in the area of climate change and engaging stakeholders in the policy development process.

The **Intergovernmental Committee on Climate Change** (IGCCC) has been established to facilitate co-ordination, co-operation and alignment between national and provincial government departments. The IGCCC is a delivery forum for the Presidential Outcome agreed at the Cabinet Lekgotla in January 2010 which aspires to achieve ‘Environmental assets and natural resources that are well protected and continually enhanced’(1). The IGCCC was also the principal technical structure driving the development of the National Climate Change Response Policy.

The **National Committee on Climate Change** (NCCC) is designed to provide representation from the main stakeholder groups involved in climate change issues across South African society. It is an open forum and composition changes with representatives from the following stakeholder groups:

- Business and Industry;
- National Government Departments;
- Provincial Environment Departments;
- Local Government;
- DEA Public Entities (SA National Biodiversity Institute and SA Weather Service); and
- Non-Governmental and Community Based Organisations.

Under the current status of South Africa as a non-annex 1 country, there are no imminent plans to implement emissions targets. The South African Government has policies and legislation in place to mitigate emissions. However, as international carbon markets grow, new opportunities may be identified to involve South African companies. Local businesses can currently participate in the carbon market through the Carbon Trading Scheme and generate revenue.

3.5.4 **International World Bank Guidelines**

The following World Bank Guidelines and Performance Standards are applicable to Gamsberg’s activities in South Africa with respect to greenhouse gas emissions, and are described in more detail below.


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• General Environmental Health and Safety (EHS) Guidelines: Environmental air emissions and ambient air quality (April 30, 2007).

**IFC Performance Standard 3: Resource Efficiency and Pollution Prevention**

The requirements of Performance Standard 3 with respect to GHG emissions are detailed in *Error! Reference source not found.*.

**Box 3.1 IFC Performance Standard 3**

In addition to the resource efficiency measures..., the client will consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project. These options may include, but are not limited to, alternative project locations, adoption of renewable or low carbon energy sources, sustainable agricultural, forestry and livestock management practices, the reduction of fugitive emissions and the reduction of gas flaring.

For projects that are expected to or currently produce more than 25,000 tonnes of CO₂ equivalent annually\(^1\), the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary\(^2\), as well as indirect emissions associated with the off-site production of energy\(^3\) used by the project. Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognized methodologies and good practice\(^4\).

1. The quantification of emissions should consider all significant sources of greenhouse gas emissions, including non-energy related sources such as methane and nitrous oxide, among others.
2. Project-induced changes in soil carbon content or above ground biomass, and project-induced decay of organic matter may contribute to direct emissions sources and shall be included in this emissions quantification where such emissions are expected to be significant.
3. Refers to the off-site generation by others of electricity, and heating and cooling energy used in the project.
4. Estimation methodologies are provided by the Intergovernmental Panel on Climate Change, various international organizations, and relevant host country agencies.

Guidance on compliance with this standard is provided in Guidance Note 3 relating to Performance Standard 3: Resource Efficiency and Pollution Prevention and focuses specifically on:

• The methodology to be used for quantifying emissions, namely the use of the 2006 IPCC Guidelines;

• Examples of project activities that may result in greater than 25,000 tons CO₂ equivalent per year; and

• Guidance on evaluating greenhouse gas performance of projects.

Although not a formal requirement under Performance Standard 3, clients are encouraged to disclose their GHG emissions annually through corporate reports, or through other voluntary disclosure mechanisms currently being
used by private sector companies internationally such as the Carbon Disclosure Project (1).

### 3.5.5 Carbon Tax and Carbon Trading Schemes

A number of countries have proposed carbon taxes. A carbon tax establishes a price for carbon, aiming to encourage a set amount of mitigation. While “guessing” the price of carbon to get to mitigation may be suboptimal, proponents of a carbon tax argue that its greater price stability reduces carbon price risk and encourages greater investment in alternative energy. Carbon taxes can also be effective for sectors where the transaction costs of cap-and-trade would make such a regime inefficient.

Proponents of cap-and-trade, which is the system used in the Europe, Australia and New Zealand and is under investigation in other countries, argue that while the variability of carbon prices inherent in such a system reduces investor certainty, cap-and-trade allows mitigation to be achieved in the most efficient way possible. This is because cap-and-trade sets a policy-driven cap, motivated by scientific evidence, and market mechanisms then allow those regulated entities with the lowest cost of mitigation to reduce emissions, and to sell excess certificates to emitters with higher marginal costs of mitigation.

South Africa’s National Treasury has developed a carbon pricing framework. Government has explored the possibility of using emissions trading as a flexible mechanism to promote emission reductions in South Africa but the highly concentrated nature of the energy markets (Goldblatt, 2010 (2)) (dominated by Eskom and Sasol) make design of this system to ensure liquidity and effective pricing complex.

The carbon tax pricing framework is based on a base rate of 120 ZAR per tonne of CO₂, with a 60% tax free threshold on the total annual carbon emissions. The introductory phase will be through to 2020 after which the rates and framework could be reviewed. Table 3.5.1 illustrates the proposed carbon tax pricing framework, and the different variables that can decrease or increase your tax-free threshold depending on characteristics of the sector, processes involved and carbon emissions.

### Table 3.6 Carbon Tax Pricing Framework

<table>
<thead>
<tr>
<th>Sector</th>
<th>Basic Tax Free Threshold</th>
<th>Max. Trade Exposure Allowance</th>
<th>Process Emission Allowance</th>
<th>Total</th>
<th>Maximum Offset Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>60%</td>
<td>-</td>
<td>-</td>
<td>60%</td>
<td>10%</td>
</tr>
<tr>
<td>Petroleum (coal to liquid)</td>
<td>60%</td>
<td>10%</td>
<td>-</td>
<td>70%</td>
<td>10%</td>
</tr>
<tr>
<td>Petroleum - oil refinery</td>
<td>60%</td>
<td>10%</td>
<td>-</td>
<td>70%</td>
<td>10%</td>
</tr>
<tr>
<td>Iron &amp; steel</td>
<td>60%</td>
<td>10%</td>
<td>10%</td>
<td>80%</td>
<td>5%</td>
</tr>
<tr>
<td>Aluminium</td>
<td>60%</td>
<td>10%</td>
<td>10%</td>
<td>80%</td>
<td>5%</td>
</tr>
<tr>
<td>Cement</td>
<td>60%</td>
<td>10%</td>
<td>10%</td>
<td>80%</td>
<td>5%</td>
</tr>
</tbody>
</table>

(1) www.cdproject.net  
Although the implementation date of the carbon tax has not been finalised, it is likely to come into effect within the next one to three years. All industries will receive a 60% tax-free threshold in the initial phase of the tax for the period until 2020. An installation could receive additional reprieves on its carbon tax exposure if it is exposed to international trade and/or if some of its fossil fuel results in process emissions. Depending on the industry categorisation, these reprieves are between 5% and 10% of the total taxable emissions (as shown in Table 3.5.1). An installation can further reduce its carbon tax exposure by 5% to 10% if it utilises carbon credits as offsets against the carbon tax. The total carbon tax rebate cannot exceed 90%.


### 3.5.6 South African National Climate Change Response White Paper

According to the National Climate Change Response White Paper, South Africa will build the climate resilience of the country, its economy and its people and manage the transition to a climate-resilient, equitable and internationally competitive lower-carbon economy and society. This will be done in a manner that simultaneously addresses South Africa’s over-riding national priorities for sustainable development, job creation, improved public and environmental health, poverty eradication, and social equality. In this regard, South Africa will:

- Effectively manage inevitable climate change impacts through interventions that build and sustain South Africa’s social, economic and environmental resilience and emergency response capacity.

- Make a fair contribution to the global effort to stabilise GHG concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner.

### 3.5.7 General EHS Guidelines: Environmental Air Emissions and Ambient Air Quality

The only section applicable to the greenhouse gas study within the General EHS Guidelines: Environmental air emissions and ambient air quality section describes sectors that may have potentially significant emissions of greenhouse gases and provides general recommendations for mitigation, which are in line with those...
described in *Performance Standard 3*. Recommendations for reduction and control of greenhouse gases include:

- Carbon financing;
- Enhancement of energy efficiency;
- Protection and enhancement of sinks and reservoirs of greenhouse gases;
- Promotion of sustainable forms of agriculture and forestry;
- Promotion, development and increased use of renewable forms of energy;
- Carbon capture and storage technologies;
- Limitation and / or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy (coal, oil, and gas).
3.6 IMPACT ASSESSMENT

3.6.1 Introduction

A traditional impact assessment is conducted by determining how the proposed activities will affect the state of the environment described in the baseline. In the case of greenhouse gas emissions, this process is complicated by the fact that the impact of greenhouse gas emissions on the environment cannot be quantified within a defined space and time.

The greenhouse effect occurs on a global basis and the point source of emissions is irrelevant when considering the future impact on the climate. Carbon dioxide has a residence time in the atmosphere of approximately 100 years by which time emissions from a single point source have merged with other anthropogenic and natural (e.g., volcanic) greenhouse gas emissions.

The global nature of the impacts of climate change such as temperature changes increases, changes in crop productivity, disease distribution etc are discussed in Appendix A. It is not possible to link emissions from a single source to particular impacts in the broader study area. This specialist study, therefore, looks at the impact of the project on South Africa’s National GHG Inventory and the implications of this rather than the physical impacts of climate change.

The remainder of this section looks at the downstream impact of the project on global emissions, assesses the impact of the Gamsberg Facility on South Africa’s national GHG inventory and compares the estimated operational emissions intensity of the project with other Zinc Ore projects around the world.

3.6.2 Cumulative Impacts

Traditionally, the cumulative effect of different sources of a common potential impact (e.g., effluent discharge or air pollution) is assessed to understand how the activities in question contribute to the overall impact on the environment described in the baseline.

Given the global nature of climate change already discussed, the cumulative impact of the Gamsberg Facility in terms of emissions is discussed in relation to South Africa’s national future emission scenarios rather than in comparison with a selection of new facilities. Given the absence of long term emission scenarios in South Africa, the emissions projections based on GDP growth have been used as the frame of reference for assessing the cumulative impacts. This is discussed further below.

3.6.3 Assessment of Impacts – South Africa’s National GHG Inventory

The impact of the estimated Gamsberg operational emissions against South Africa’s national GHG inventory has been assessed by comparison with an emissions trajectory from 2011 to 2035 which has been determined based on historic and projected economic growth and development pathways as illustrated in Figure 3.3.2. Total emissions in South Africa in the most recent,
2000, GHG inventory amount to 442.29 million tCO$_2$e. The estimated emissions of GHG into the atmosphere by Gamsberg facilities, as well as the associated increase in South Africa’s national emissions are shown in Table 3.6.1.

Table 3.7 Comparison of Gamsberg with Projected National Emissions (tCO$_2$e)

<table>
<thead>
<tr>
<th>Year</th>
<th>SA National Emissions (excl. Gamsberg)</th>
<th>Gamsberg estimated emissions</th>
<th>SA National Emissions (incl. Gamsberg)</th>
<th>% Increase in national emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>740 313 419.21</td>
<td>552 449</td>
<td>740 865 868</td>
<td>0.07%</td>
</tr>
<tr>
<td>2016</td>
<td>766 594 545.59</td>
<td>552 449</td>
<td>767 146 995</td>
<td>0.07%</td>
</tr>
<tr>
<td>2017</td>
<td>793 808 651.96</td>
<td>552 449</td>
<td>794 361 101</td>
<td>0.07%</td>
</tr>
<tr>
<td>2018</td>
<td>821 988 859.11</td>
<td>552 449</td>
<td>822 541 308</td>
<td>0.07%</td>
</tr>
<tr>
<td>2019</td>
<td>851 169 463.61</td>
<td>552 449</td>
<td>851 721 913</td>
<td>0.06%</td>
</tr>
<tr>
<td>2020</td>
<td>881 385 979.56</td>
<td>552 449</td>
<td>881 938 429</td>
<td>0.06%</td>
</tr>
<tr>
<td>2021</td>
<td>912 675 181.84</td>
<td>552 449</td>
<td>913 227 631</td>
<td>0.06%</td>
</tr>
<tr>
<td>2022</td>
<td>945 075 150.79</td>
<td>552 449</td>
<td>945 627 600</td>
<td>0.06%</td>
</tr>
<tr>
<td>2023</td>
<td>978 625 318.65</td>
<td>552 449</td>
<td>979 177 768</td>
<td>0.06%</td>
</tr>
<tr>
<td>2024</td>
<td>1 013 366 517.46</td>
<td>552 449</td>
<td>1 013 918 966</td>
<td>0.05%</td>
</tr>
<tr>
<td>2025</td>
<td>1 049 341 028.83</td>
<td>552 449</td>
<td>1 049 893 478</td>
<td>0.05%</td>
</tr>
<tr>
<td>2026</td>
<td>1 086 592 635.35</td>
<td>552 449</td>
<td>1 087 145 084</td>
<td>0.05%</td>
</tr>
<tr>
<td>2027</td>
<td>1 125 166 673.91</td>
<td>552 449</td>
<td>1 125 719 123</td>
<td>0.05%</td>
</tr>
<tr>
<td>2028</td>
<td>1 165 110 090.83</td>
<td>552 449</td>
<td>1 165 662 540</td>
<td>0.05%</td>
</tr>
<tr>
<td>2029</td>
<td>1 206 471 499.06</td>
<td>552 449</td>
<td>1 207 023 948</td>
<td>0.05%</td>
</tr>
<tr>
<td>2030</td>
<td>1 249 301 237.27</td>
<td>552 449</td>
<td>1 249 853 686</td>
<td>0.04%</td>
</tr>
<tr>
<td>2031</td>
<td>1 293 651 431.20</td>
<td>552 449</td>
<td>1 294 203 880</td>
<td>0.04%</td>
</tr>
<tr>
<td>2032</td>
<td>1 339 576 057.00</td>
<td>552 449</td>
<td>1 340 128 506</td>
<td>0.04%</td>
</tr>
<tr>
<td>2033</td>
<td>1 387 131 007.03</td>
<td>552 449</td>
<td>1 387 683 456</td>
<td>0.04%</td>
</tr>
<tr>
<td>2034</td>
<td>1 436 374 157.78</td>
<td>552 449</td>
<td>1 436 926 607</td>
<td>0.04%</td>
</tr>
<tr>
<td>2035</td>
<td>1 487 365 440.38</td>
<td>552 449</td>
<td>1 487 917 889</td>
<td>0.04%</td>
</tr>
</tbody>
</table>

Table 3.7 shows the annual percentage increase in national emissions during the Gamsberg project. It is evident that the Gamsberg facilities will result in a minor (0.07%) increase in annual emissions, however, the impact will be over a long period of time.

3.6.4 The Gamsberg Facility in Relation to South Africa Specific Issues

It is evident then that the Gamsberg Facility’s emissions will increase the level of South Africa’s emissions by less than 1% when operations begin. To determine whether this is significant or not, the increase in emissions is discussed against South Africa specific issues:

Annual Emissions Increase

The emission projection based on GDP growth assumes a 3.6% increase in emissions annually as discussed in Section 3.3.3.1 above. Since there is no actual data upon which to base this assumption it is not possible to assess whether this figure is an over or under estimate of future emissions. Assuming that emissions will increase by 3.6% per year, the addition of the Gamsberg facility will increase South Africa’s emissions by an equivalent amount during the first
few years of operation, reducing each year as national emissions rise (as set out in Table 3.7). Should the country’s emissions growth be less than 3.6% then this project could add more emissions to the atmosphere per year than the annual increase from the entire country. Conversely, if the growth rate is higher than 3.6%, or if a significant development (e.g., large oil and gas refinery) is commissioned which increases the country’s emissions significantly, then the impact of Gamsberg will be less.

**Future Greenhouse Gas Regulation**

South Africa, as a Least Developed Country, does not currently have an obligation to reduce greenhouse gas emissions. The country’s main focus in relation to climate change is to ensure the safety of vulnerable communities, environments and infrastructure in the face of changing disease distribution, crop productivity and extreme weather events such as droughts, floods and storms.

However, the government acknowledges the need for South Africa to play its part in the international response to climate change but needs finance, technology and capacity building in order to do so. Whilst there is unlikely to be legislation on emissions in the short term, the international community will be looking to South Africa to develop a green, low emissions economy and given the high emissions associated with its operations, Gamsberg and other mines in the country may face pressure to reduce emissions voluntarily.

**Benchmark Against International Zinc Mines**

Benchmarking emissions intensity of the Gamsberg project against other Zinc mines provides a measure of its performance against the industry average. The emissions intensity of zinc mines is influenced by a range of internal (technology) and external (environmental/geographic) factors as indicated in Figure 3.6.2.

The production capacity of Gamsberg is 10 million tonnes of zinc ore per annum. With an estimated annual carbon footprint of 552,449 tCO₂e for the Gamsberg activities, this is equivalent to 0.055 tCO₂e/tonne zinc ore. This is compared with the intensity of other zinc ore mining projects under operation around the world, and is illustrated in Figure 3.7.
Without mitigation, the proposed project will increase greenhouse gas emissions in South Africa by approximately by less than 1%.

In order to conclude whether this impact is deemed significant or not, a risk classification approach is used. The approach is derived from classic risk assessment nomenclature which involves the expression of risk as the consequence of the event multiplied by the probability of that event. The environmental assessment equivalent is the magnitude of the impact multiplied by the likelihood of the impact. Impact magnitude is a function of the potential intensity of the impact moderated by the extent and duration of that impact. Expressed mathematically impact significance is:

\[(\text{Intensity} + \text{extent} + \text{duration}) \times \text{likelihood} = \text{impact significance}\]

Table 3.6.2 illustrates characteristics utilised to assess the significance of the impact of the project on national emissions, based on ERM’s methodology for impact assessments as presented in the Gamsberg ESIA Report.

### Table 3.8 Assessment of Significance

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>The extent of the impact is <strong>national</strong> as it is South Africa’s greenhouse gas emissions that are directly increased due to the impact of the project. Although the greenhouse effect is <strong>transboundary</strong> and global emissions are directly affected, this project assesses the impact on South Africa’s emissions.</td>
</tr>
<tr>
<td>Duration</td>
<td>The duration of the impact is regarded as <strong>permanent</strong> as science has indicated that the persistence of carbon dioxide in the atmosphere is said to range between 100 and 500 years and therefore continues beyond the life of the project.</td>
</tr>
<tr>
<td>Frequency</td>
<td>The substantial increase in South Africa’s national greenhouse gas emissions will be <strong>constant/periodic</strong> as the Gamsberg project will be operational for 20 years.</td>
</tr>
</tbody>
</table>
Scale
The substantial increase in South Africa’s national greenhouse gas emissions and the long residence time in the atmosphere would indicate that the impact would have a **medium** scale during operations. Functions and natural processes will be notably altered in the long term.

Intensity
The substantial increase in South Africa’s national greenhouse gas emissions and the long residence time in the atmosphere would indicate that the impact would have a **high** intensity during the operational phase when emissions are orders of magnitude higher.

Likelihood
The probability of the impact of increased levels of greenhouse gas emissions with the proposed project is regarded as **certain**.

Magnitude
Given the far-reaching and permanent nature of the impacts as well as the high intensity of the impact on South Africa’s national emissions, the magnitude of the negative impacts is considered to be **high** during the operational phase.

**Magnitude is a function of Extent, Duration, Scale, Frequency, and Likelihood.**

The remainder of this section assesses the significance of the impact of the project on South Africa’s national emissions, based on ERM’s methodology for impact assessments as presented in the *Gamsberg ESIA Report*.

**Assessing Significance**

In light of the above, the significance of the impact of the emissions from the Gamsberg Facility of South Africa’s national emissions can be considered as **moderate** as illustrated in *Error! Reference source not found.*.

**Table 3.9  ERM Impact Assessment Significance Rating**

<table>
<thead>
<tr>
<th>Magnitude of Impact</th>
<th>Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Small</td>
<td>Negligible</td>
</tr>
<tr>
<td>Medium</td>
<td>Minor</td>
</tr>
<tr>
<td>Large</td>
<td><strong>Moderate</strong></td>
</tr>
</tbody>
</table>

The potential magnitude of the impact is highly uncertain and involves unique/unknown risks. However, according to current designs, there is high confidence that the significant greenhouse gas emissions from the Gamsberg Facility would have a **moderate** impact on South Africa’s national emissions. *Box 3.6.1* provides a summary of the impact of the Gamsberg facilities.
Box 3.2

Summary of Impacts: Greenhouse Gas Emissions

| Nature: GHG Emissions from the Gamsberg facilities. |
| Sensitivity/Vulnerability/Importance of Resource/Receptor – High |
| Irreplaceability: The activity will result in the long term changes to climate change, which is irreversible and irreplaceable |

Impact Magnitude – Medium

- **Extent:** The extent of the impact is national
- **Duration:** The expected impact will be permanent (ie irreversible)
- **Scale:** The impact will result in notable changes to the resource/ receptor
- **Frequency:** The frequency of the impact will be continuous
- **Likelihood:** National GHG emissions will certainly increase

**IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE**

**Degree of Confidence:** The degree of confidence is high.

Based on above assessment that the magnitude of the impact of the Gamsberg Facility on South Africa’s national emissions, short and long term, could be medium and the definite likelihood of the impact occurring, the significance of the impact is rated as **Moderate.**

3.6.6

**Overall Impact on South Africa’s National Emissions**

In conclusion, the following assumptions can be defined:

- The impacts of climate change are global in nature;

- South Africa’s emissions were relatively low in 2000 but based on GDP growth rate are projected to grow significantly in the coming decades;

- The Gamsberg Facility is estimated to emit approximately 552 449 tonnes of tCO\(_2\)e per year during full operation;

- Without mitigation, the proposed project will increase greenhouse gas emissions in South Africa by approximately by less than 1%;

- The Gamsberg Facility has relatively low emissions intensity in comparison with other zinc ore projects around the world;

- The South African government acknowledges the need for the country to play its part in the international response to climate change; and

- Gamsberg may face pressure from shareholders and the international community to reduce emissions voluntarily.
3.7 RECOMMENDATIONS FOR POTENTIAL EMISSION REDUCTION ACTIONS

3.7.1 Introduction

Given its global nature, mitigation of the impact of climate change takes the form of reducing the concentration of greenhouse gases in the atmosphere. Vedanta has an opportunity to influence the overall impact of the Gamsberg Facility and associated activities on GHG emissions by ensuring that the final design includes the most energy efficient and low emissions options available.

This section identifies a number of best practice options to be considered for the Gamsberg Project in order to increase the energy efficiency and/or emissions intensity of its activities in South Africa and thereby reduce Scope 1, 2 and 3 emissions. These options include:

• Stationary Combustion, Predominantly for Electricity Production;
• Energy Efficiency and Renewable Energy;
• Transport;
• Waste Management;
• Business Travel;
• Carbon Capture and Storage; and
• Reduced Deforestation and/or Offsets.

Given the early stage in the design of the project, it was not possible to accurately estimate the abatement potential of each option. These activities will, however, contribute towards the sustainability of the project, reducing the greenhouse gas emissions, and reducing costs (eg fuel use for electricity generation).

3.7.2 Greenhouse Gas Mitigation Initiatives

Stationary Combustion and Electricity

A significant source of CO$_2$e emissions that contribute to the carbon footprint is the result of electricity usage. Alternative sources of electricity produced from renewable energy sources, or a mix thereof, should be considered so as to reduce overall energy consumption:

• **Biofuels:** In the near future there is potential for biofuels to be readily available (Booyens 2012). This includes both biodiesel and ethanol fuels which will greatly reduce the CO$_2$e emissions. Biodiesel-diesel fuel mixes can be used in most diesel generators in a mix that includes up to 20% biodiesel without having to modify the engines (NREL 2009).

• **Solar photovoltaics:** As part of the energy system, solar photovoltaics can take some of the pressure off of the carbon intensive power generation. Solar power can be applied to offices, accommodation and other buildings.
• **Tri-generation:** This process involves the simultaneous generation of electricity and useful heating and cooling from the combustion of a fuel (such as natural gas) or a solar heat collector. The supply of high-temperature heat first drives a gas or steam turbine powered generator and the resulting low-temperature waste heat is then used for water or space heating and cooling.

**Energy Efficiency and Renewable Energy**

The majority of emissions linked to offices and accommodation are associated with electricity use and heating/cooling. By building well insulated buildings which utilise renewable energy and efficient cooling systems, the carbon footprint associated with these activities will be reduced as will the cost of fuel and energy. There are a number of initiatives which can be implemented when constructing the camps and offices which will help reduce electricity consumption and GHG emissions. Whilst the majority of these initiatives may not significantly reduce the overall carbon footprint, they would improve the efficiency of the buildings. Initiatives include:

• **Solar power** - significant reductions in fuel costs and electricity use from offices, accommodation and other buildings can be expected if hot water is heated by solar water heaters and photovoltaic panels that can supplement fossil fuel generated electricity.

• **Heat pumps** – Applying heat pumps to water heating systems or HVAC systems can be significantly more efficient than conventional heating/cooling system. The heat transferred can be 3-4 times higher than the electricity consumed (UNEP 2009).

• **Insulation** – well insulated walls and ceilings will reduce temperature extremes within the buildings leading to more comfortable living/working conditions and reduced air conditioning requirements.

• **Lighting** – use of natural light where possible and compact fluorescent or LED lighting throughout the site will reduce electricity consumption;

• **HVAC energy efficiency** (air conditioning and heating) - Heating, Ventilation and Air Conditioning - reducing energy use by operational changes in use, replacement or upgrade of air handling systems and improving air conditioning controls.

• **Refrigerants** – energy efficient air conditioners which use refrigerant gases with a low global warming potential (such as R134)\(^1\) could reduce CO\(_2\)e emissions resulting from air conditioning (Bitzer 2011).

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(1) Refrigerant emissions are calculated by the amount of refrigerant that is replaced on a yearly basis. Standard refrigerants have very high global warming potentials (GWP) making them a potentially high emission source. However, international regulation are phasing out harmful refrigerants and new refrigerants will very low GWP are available.
• **Fugitive Emissions**, emissions arise from the escape of gases, should be reduced, recovered and/or reused so as to reduce emissions and safety.

• Buildings (particularly offices) should be fitted with sensors, timers and **control systems** which allow lights and equipment to switch off or go onto stand by when not in use (eg overnight).

• **Metering and Submetering** - Installation of meters and sub meters for internal electricity use monitoring and management. For an administration building this may include: chillers, air handling units (AHUs), lighting and parking areas. This will allow the identification of energy consumption and electrical base load reduction opportunities which will in turn result in emission and monetary savings.

• **Training and awareness** for behaviour change could result in decreased consumption (eg switching off lights/geysers).

All of the above will contribute towards emission savings and thereby reduce the overall operational carbon footprint of the site.

**Transport**

Diesel trucks and mining vehicles are expected to emit a high level of CO$_2$e emissions during the operations phase. There are several efforts that could be made to minimise the emissions:

• **Optimisation of transport logistics** (eg equipment, products and people) and the use of energy efficient vehicles and machinery will reduce fuel consumption and therefore GHG emissions.

• **Institute fuel efficient driving rules** such as to avoid idling, drive at reduced speeds, avoid excessive breaking. This should be enforced through driving training and health and safety awareness.

• **Fuel Additives and Catalysts for Fuel Savings** - many diesel fuel additives are able to significantly reduce hydro carbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx) and particulate matter (PM). This reduction is due to an increase in complete combustion. Oxides of nitrogen can be reduced by 10-45%, and PM can be decreased by 30-70%.

In the near future there is potential for biofuels to be readily available (Booyens 2012). For vehicles, biofuel mixing should be considered to reduce CO$_2$e emissions. Many vehicle systems are able to run on lower mix-ratios without having to convert the engine. This includes B5, B10 or B20 grades of biodiesel fuel mixtures (NREL, 2009) and up to E20 grades of ethanol-petrol mixtures (DOE, 2008).
Waste Management

A waste management system should be established to minimise waste. Considerations should include reducing all types of waste and recycling/reusing waste. Unavoidable carbon based solid wastes should be treated in a thermal oxidiser (incinerator) and/or utility boilers.

Possible options for the treatment of waste water (sewage) from the site include:

- Standard treatment and reuse of waste water for industrial purposes, and solids being disposed of at sea or used as compost.

- Organic rich waste can be filtered through man-made mangroves to clean the water naturally and to sequester carbon deep within the mangrove root systems and soil and thus acting as a carbon sink.

Business Travel

Face to face meetings are an integral part to most businesses; however, unnecessary travel can be minimized to save on time and carbon emissions. A travel policy should be instituted to encourage technological alternatives like video conferencing, teleconferencing and web-based meetings.

Reduced Deforestation and/or Offsets

Land clearance in advance of construction of the facility can be offset by progressive rehabilitation of unused land on site as well as a ‘biodiversity offset’ elsewhere in the region which will could act as a carbon sink and offset some, if not more than the emissions from land clearance. Whilst not contributing to a reduction in Gamsberg’s direct carbon footprint, it supports national efforts to reduce deforestation and to improve air quality and living standards in rural communities.

3.7.3 Recommendations for Mitigation

Recommendations regarding the Gamsberg Project include the following:

- Consider effective driving and vehicle use to optimize transport as well as heavy (mining) vehicle use.

- Consider minimizing business travel.

- Optimise transport logistics.

- Incorporate ‘green building’ features in the design of offices and accommodation; particularly the type of refrigerant to be used when choosing cooling technology by considering the global warming potential of the selected refrigerant.
• Implement at outset a high efficiency equipment purchasing policy on maintenance and replacement policy on motors and pumps.

• Consider alternative energy technologies for electricity supply.

• Consider the development of a waste to energy plant for non-hazardous, carbon-based waste.
In order to comply with the IFC requirements for annual reporting of GHG emissions, it is important for an effective and efficient data management system to be implemented from the start. The system can be used to monitor a range of sustainability indicators in addition to energy use and emissions such as water, biodiversity, health and safety etc. A robust carbon management strategy and carbon/sustainability reporting framework could be developed which should:

- Develop a **management and reporting policy** to provide direction and commitments to sustainable development and carbon reporting.

- Outline **reporting procedures** in light of this policy.

- Assign **roles and responsibilities** to ensure effective implementation of both internal and external carbon and sustainability reporting requirements.

- Define **timing for data reporting** - quarterly reporting of data will enable Vedanta to monitor progress against targets, facilitate effective progress on annual sustainability reporting and carbon management and ensure the integration of sustainability into the business.

- Develop a robust **monitoring and reporting methodology** detailing calculations and measurements, estimations, assumptions, definitions, conversion factors etc. In the case of measurements this should include: the type and frequency of sampling; checks on the reliability of tests; corrective measures; instructions regarding missing data etc. If Vedanta has formal ISO14001 management systems in place there is an opportunity to integrate ‘monitoring and reporting’ of environmental data into the Environmental Management Systems (EMS) in terms of formalised procedures and controls. The monitoring and reporting of the full range of environmental parameters could be included and driven under the ‘other requirements’ clause of ISO 14001. It is recommended that duplication of systems is minimised and existing management systems be used as a ‘vehicle’ providing the framework of procedures (controls) and audit trails (documented evidence) required for reporting and auditing purposes.

- Compile a **‘Carbon Reporting Operating Manual’** to provide guidance on data requirements, achieve consistency in definition interpretation and establish the foundation for an audit trail for future data verification.

- Report on GHG emissions and sustainability performance annually to investors, shareholders and the public (eg through Vedanta’s Sustainability Report).
REFERENCES


SAWS, 2012. WB42 for Pofadder.


Appendix A

The Climate Challenge
APPENDIX A: THE CLIMATE CHALLENGE

This Appendix presents background information on climate change to provide context.

The Greenhouse Effect

The earth is a complex system with geological, hydrological, biological and atmospheric cycles intimately linked by a series of positive and negative feedback interactions causing fluxes in the concentration of greenhouse gases in the atmosphere and the global mean surface temperature over millennia. The earth system is also affected by external influences such as the intensity of solar radiation and its orbit around the sun.

Solar radiation entering the atmosphere is absorbed by the earth’s surface and then re-radiated as infrared radiation. Some of this infrared radiation is absorbed by certain “greenhouse” gases in the atmosphere, preventing its return to space. Without the regulating influence of the atmosphere, the earth’s mean surface temperature would be 30°C colder than today’s ambient 15°C. The “greenhouse effect” is the key mechanism for trapping warmth from the sun in the atmosphere.

There is consensus that human activity, through the emission of greenhouse gases, has significantly contributed to the observed warming since the pre-industrial revolution era\(^{(1)}\). As a result, over the last 100 years the global average surface temperature has increased by 0.74°C. Six of the warmest years on record occurred between 1995 and 2006 corresponding to increased levels in Carbon Dioxide (CO\(_2\)) emissions in the same period (IPCC, 2007).

The Impact of Climate Change

The increase in temperature associated with rising CO\(_2\) concentrations could have significant consequences on the earth system. Changes in temperature will affect weather patterns which may result in more extreme precipitation events, storms, droughts etc. Melting ice caps and glaciers and thermal expansion of the oceans are projected to increase sea levels. These may have knock-on implications for many aspects of the environment and human society.

According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment report published in 2007, key impacts projected for Africa for the period 2020 to 2050 include the following:
- 75 to 250 million people will experience greater water stress by 2020;
- Rain-fed agricultural yields could be reduced by 50% by 2020 in some countries;
- 10-30% reduction in average river run-off and water availability by \(\sim\)2050;

• Drought-affected areas will increase in extent;
• Flood risk in high rainfall areas will increase;
• Ecosystem structures will change and there will be a loss of biodiversity if temperatures increase more than 1.5 to 2.5°C;
• Human health challenges will arise, eg possible changes in malaria transmission potential.

It is widely accepted that climate change has already begun to affect physical and biological systems, including people, and that current concentrations of GHGs (which are still increasing at an accelerating rate) commit the world to at least 2°C warming and probably 2.4 °C\(^{(1)}\), and hence continued environmental change. Both the Millennium Ecosystem Assessment and the IPCC Fourth Assessment Report, outline the effects of global climate change, including more frequent extreme weather events, rising sea levels, water shortages, threats to food security, disease and other health effects. *Figure A.1* outlines these effects in relation to global temperatures and their severity.

*Figure A.1*  The impact of rising temperatures on natural systems\(^{(2)}\)

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On average the world is currently 0.74°C warmer than it was 100 years ago which implies that the physical and biological changes identified by the IPCC that appear to the left of the red line (at 0.74°C) Figure A.1 are already taking place. Current concentrations of GHGs in the atmosphere almost certainly commit the world to a 2.2°C temperature rise by 2050, implying that the changes to the left of the purple line are inevitable.

Climate change projections for South Africa

Every five to six years, the Intergovernmental Panel on Climate Change (IPCC) analyses on-going climate trends and predicts future climate by the end of the century using a wide variety of models and a predefined set of global greenhouse gas emission scenarios. The latest findings are included in their Fourth Assessment Report that was published in 2007. The projections carry a degree of likelihood at a global level. At the scale of the study area and the presumed operational lifetime of the project, it is far more difficult to establish climate change projections and likely consequences for the study area.

Much work is taking place within research institutions in South Africa to ‘downscale’ the global climate models and identify key vulnerabilities in South Africa. The key message is that water availability is going to become even more of an issue to business and life in South Africa than it is at the moment. The western part of the country is expected to experience significant drying. The eastern part of the country could receive the same, if not more precipitation, but with changing patterns leading to more extreme rainfall events and longer dry periods (1). Temperatures are also expected to rise 2 - 6°C by the middle and end of the century, with the highest rises in the most arid parts of the country (2).

Key risks of climate change for a water-stressed country such as South Africa include threats to water supplies and changing rainfall patterns. Temperature increases could enlarge the areas that are prone to malaria and other vector-borne diseases. Temperature changes could also pose various challenges to crop cultivation. Higher carbon dioxide levels could reduce proteins in grasslands and livestock producing areas, particularly in poorer, drier parts of the country. Fisheries and the livelihoods of fishing communities will also be affected by changes in the sea temperature. The impact of climate change is increasingly emerging as possibly the greatest threat to biodiversity loss. For example, the Cape Floral Kingdom could be significantly reduced, with negative economic impacts in the tourism sector.

Future emission constraints

The IPCC has modelled scenarios for stabilising greenhouse gas emissions in the atmosphere and the impact different levels may have on global surface

(1) Presentation by Professor Roland Schulze from the School of Bioresources, Engineering and Environmental Hydrology at the University of KwaZulu Natal July 2010.
(2) Schulze (2010)
temperatures. *Figure A.2* shows historic CO₂ emissions from 1940 to 2000 and the range of emissions for stabilisation scenarios from 2000 to 2100 (chart on left); and the corresponding relationship between these scenarios and the likely equilibrium global average temperature increase above pre-industrial levels (chart on right) (IPCC 4AR, 2007). As an example, stabilisation level VI (chart on left) will result in an equilibrium global average temperature increase above pre-industrial temperatures of between 3.5 and 8.5°C (chart on right) or, stabilisation level I (chart on left) will result in an equilibrium global average temperature increase above pre-industrial temperatures of between approximately 1.75 and 3.75°C (chart on right).

*Figure A.2* Global CO₂ stabilisation scenarios and associated temperature change

Approaching equilibrium may take several centuries (particularly for higher stabilisation levels). The key point to take from *Figure A.2* is that if we are to stabilise concentrations at levels which result in a 2-4°C temperature increase, global emissions need to peak by 2020 and reduce to pre-industrial levels by 2100 (ie stabilisation level I).

Evidence of the physical effects of climate change are becoming evident and are having a significant financial impact on business and governments eg the recent floods in Australia, the USA and Pakistan, Cyclone Nargis (Burma, 2008), Hurricane Katrina (USA, 2005), the 2003 European heat wave, and numerous large scale flooding events every year.

In order to limit the projected increase in global average temperature to below 2°C above pre-industrial levels, global GHG emissions will have to peak by 2020 at the latest and reduce by a least 50% as compared with 1990 levels by 2050 and continue to decline thereafter (IPCC, 2007). The IPCC have proposed that developed countries should reduce their GHGs below 1990 levels by 25-40% by 2020 and by 80-95 % by 2050 and that developing countries should achieve a substantial deviation below the currently predicted emissions growth rate, in order of 15-30% by 2020.
Appendix B

Carbon Footprint
Assumptions and
Calculations
APPENDIX B: ASSUMPTIONS AND CALCULATIONS FOR CARBON FOOTPRINT

B.1 Mobile Combustion

Road Transport

- Estimated vehicle fleet, equipment, operational hours and distance to be travelled was provided by Vedanta personnel;
- Estimated consumption rates (l/hr) for various vehicle and equipment was obtained from http://www.majuraparkway.act.gov.au/__data/assets/pdf_file/0010/229087/70-1512R4_Heggies_GHG_Report_Final_20090415.pdf;
- Total estimated litres of diesel to be consumed was calculated using the consumption rates of the vehicle/equipment type (l/hr) and the operation hours (per annum);
- Total estimated litres of diesel to be consumed by haul truck was calculated using the number of haul trucks and the total distance to be travelled (per annum);
- Emissions associated with each unit of diesel consumed was obtained from the IPCC 2006 GHG Guidelines; and
- To determine kilograms CO\textsubscript{2} per litre/km, consumption was multiplied by the emission factor provided by the IPCC 2006 GHG Guidelines.

B.2 Stationary Combustion

Diesel Use

- Estimated diesel consumption to be used during operations was provided by Vedanta;
- Emissions associated with each unit of diesel consumed was obtained from the IPCC 2006 GHG Guidelines; and
- To determine kilograms CO\textsubscript{2} per litre, consumption was multiplied by the emission factor provided by the IPCC 2006 GHG Guidelines.

B.3 Non Combustion Emissions

Lubricants and Oils

- Estimated lubricants and oils consumption was provided by Vedanta;
- Lubricants used for heavy duty machinery and equipment were considered to be fossil fuel based; and
- Emissions associated with each unit of lubricants and oils consumed was obtained from the IPCC 2006 GHG Guidelines; and
- To determine kilograms CO\textsubscript{2} per litre, consumption was multiplied by the emission factor provided by the IPCC 2006 GHG Guidelines.

B.4 Refrigerants

- Refrigerant emissions are calculated by the amount of refrigerant that is replaced on a yearly basis. Standard refrigerants have very high global warming potentials (GWP) making them a potentially high emission source;
- It was assumed that central air-conditioning units will be used for the administration central block, control rooms, medical clinic and the security and training areas;
• It was assumed that all refrigerants would be filled using the standard HFC-134a refrigerant, which has a GWP of 1300; and
• To determine CO₂ emissions, the amount of refrigerant replaced is multiplied by the GWP and converted to tCO₂e.

B.4 Explosives

• Estimated explosives to be consumption monthly was provided by Vedanta;
• Explosives will be used for blasting activities;
• Emissions associated with each unit of explosives consumed was obtained from the IPCC 2006 GHG Guidelines; and
• To determine kilograms CO₂ per tonne, consumption was multiplied by the emission factor provided by the IPCC 2006 GHG Guidelines.
• To determine CO₂ emissions, the amount of explosive replaced is multiplied by the emission factor provided by the IPCC 2006 GHG Guidelines.

B.5 Electricity

• Estimated electricity consumption annually was provided by Vedanta;
• To determine kilograms CO₂ per kWh, consumption was multiplied by the country specific electricity grid factor provided by the Eskom (Annual Report 2012); and
• To determine CO₂ emissions, the electricity consumption is multiplied by the electricity grid factor.

B.6 Waste

• Estimated waste to be generated daily was provided by Vedanta;
• To determine kilograms CO₂ per unit of waste, consumption was multiplied by the methane emission factor.
• The standard IPCC 2006 GHG guidelines were used to determine the tCO₂e emissions per annum.

B.7 Waste Water Treatment

• Estimated waste water to be treated daily was provided by Vedanta;
• To determine kilograms CO₂ per unit of waste water, consumption was multiplied by the methane emission factor.
• The biological oxygen demand treatment process was used for the waste water treatment and standard IPCC 2006 GHG guidelines were used to determine the tCO₂e emissions per year.

B.8 Business Travel and Contractors

• Indirect emissions (Scope 3) would typically be from outsourced activities, such as contractor activity and employee business travel.
• These emissions have been excluded for the purposes of this study due to the fact that there is considerable uncertainty with respect to estimating contractor activity and employee business travel.
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