SPECIALIST CLIMATE CHANGE IMPACT ASSESSMENT

For The Proposed West Wits Mining Project

Prepared by Promethium Carbon
For SLR Consulting

May 2019

Executive Summary

West Wits MLY (Pty) Ltd. has applied for a mining right in terms of the Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA) as amended, for gold, uranium and silver over various portions of farms. The proposed establishment of the West Wits Mining Project is located within the City of Johannesburg, to south of Roodepoort and the north of Soweto. The project would involve the development of five open pit mining areas and refurbishment of two existing infrastructure complexes. The re-mining of the area could potentially assist in mitigating negative legacy mining impacts in the area and as a result addressing historical spatial discontinuity between the northern and southern parts of Johannesburg in the long-term.

Promethium Carbon has been appointed to undertake a specialist climate change assessment of the project. This involves assessing the project's prospective contribution to climate change through the emission of greenhouse gases (GHGs) such as carbon dioxide (CO_2), as well as the impact of climate change on the mine's core operation, value chain and social as well as natural environment.

This specialist climate change impact assessment was informed by Section 24 of National Environmental Management Act and the Impact Assessment Regulations as published in the Government Gazette of 20 October 2014. It is noted that the National Environmental Management Act regulations are designed to assess the impact of local pollutants, and do not provide sufficiently for the assessment of greenhouse gas emissions which have long-term[1] and global impact but cannot be directly linked to local impacts.

The specific greenhouse gas emissions from the construction and operation of the proposed West Wits mining project cannot be attributed directly to any particular climate change effects. In addition, greenhouse gas emissions from the proposed mine, when considered in isolation, will have a minimal impact on global climate change. Despite this however, climate change is a global challenge. As such there is a collective responsibility to address the global challenge of climate change and each actor, such as the proposed West Wits mine, has an individual responsibility to minimise its own negative contribution to the issue.

In order to assess climate change impacts, the greenhouse gas inventory of the proposed West Wits mine was undertaken. This inventory determined the Scope 1 (direct greenhouse gas emissions), Scope 2 (energy indirect emissions) and Scope 3 (other indirect) emissions related to both the construction and operational lifespan of the mine. Direct greenhouse gas emissions are emissions from sources that will be owned or controlled by the owner of the proposed mine. Energy indirect greenhouse gas emissions are emissions resulting from imported electricity

1 Greenhouse gas emissions can remain in the atmosphere for decades.

consumed by the proposed mine. Other indirect greenhouse gas emissions are the emissions (excluding energy indirect greenhouse gas emissions) that occur as part of the supply chain necessary for inputs into the owner's activities at the mine but occur at sources owned or controlled by another company. The project emissions are summarised in the table below:

Summary of the greenhouse gas emissions calculated for the proposed West Wits Mine

Emission categories	Construction	Operations (open cast and underground)	Total (construction and operations)
Direct (Scope 1) Emissions	619 tCO_{2e}	183 tCO_{2e}	802 tCO_{2e}
Indirect (Scope 2) Emissions	-	103 271 tCO_{2e}	103 271 tCO_{2e}
Other Indirect (Scope 3) Emissions	7 050 tCO_{2e}	123 135 tCO_{2e}	130 185 tCO_{2e}
Total Emissions	**7 669 tCO_{2e}**	**226 589 tCO_{2e}**	**234 257 tCO_{2e}**

tCO_2e – tonnes carbon dioxide equivalent

The proposed West Wits mine is expected to have **direct** emissions and **energy indirect** emissions of approximately 226 000 tonnes CO_2e over its lifetime. The majority of these emissions are as a result of electricity consumption (Scope 2 emissions) and other indirect sources specifically purchased goods and services, other fuel and energy related activities and diesel consumption for transport of goods.

It is certain that the emissions related to the West Wits mine operations, including activities undertaken by third party suppliers in terms of process inputs, will produce greenhouse gas emissions and that those greenhouse gas emissions will contribute to the national inventory and climate change.

The context within which the environmental impact assessment reporting requirements were developed to describe and assess environmental impacts as per Section 24 of National Environmental Management Act, have yet to be applied to greenhouse gas emissions that have a global impact. As such criteria were developed by the authors to assess local environmental impacts. The authors of this report have adapted the quantification of Magnitude in the assessment criteria in order to align the methodology with global impact.

The IPCC's Fifth Assessment Report (IPCC, 2014) indicates that the world can emit 1,010 gigatons of CO_2e if the effect of climate change is to be limited to a 2°C temperature increase. This is the global carbon budget. South Africa's share of this global budget is calculated based on the national population figure of 58 million people (Stats SA, 2018) as a percentage of the global population of 7.7 billion people (Worldometers, 2019). South Africa's carbon budget in this respect is therefore approximately 7,572 Mt CO_2e.

The calculated greenhouse gas inventory, specific to emissions released in South Africa, is assessed in terms of the quantity of the emissions allocated under the South African carbon budget that the West Wits mine would use-up in its lifetime. The magnitude of a project is considered high if the emissions are equivalent to 0.13% of the South African carbon budget and low if they fall below 0.00013% of the South African carbon budget.

The West Wits Project's calculated emissions inventory, in terms of South Africa's remaining portion of the global carbon budget, is presented in the following table:

West Wits Mining Project's emissions relative to South Africa's carbon budget

South Africa's carbon budget based on proportion of local population	7,572 Mt CO_2e	
West Wits Project's Total Scope 1 (lifetime)	0.00001%	
West Wits Project's Total Scope 1 & Scope 2 (lifetime)	0.001%	**of South Africa's carbon budget**
West Wits Project's Total Scope 1, Scope 2 & Scope 3 (lifetime)	0.0031%	

The **impact of the total West Wits Project's greenhouse gas inventory within a domestic context** is therefore considered to be **low-medium** because the total lifetime inventory is expected to consume approximately 0.0031% of South Africa's carbon budget. The value of 0.0031% is above the low-materiality threshold (0.00013%) but below the medium-materiality threshold (0.013%) of South Africa's carbon budget.

The greenhouse gas emissions from the proposed West Wits mine, when considered in isolation, are unlikely to have a significant impact on global climate change. However, the global atmosphere, as the receiving environment should be considered. This is done in terms of the global carbon budget as well as South Africa's carbon budget related to the 2°C temperature increase limitation.

The project significance score further needs to be considered in the context of the following:

- The Paris Agreement: The Paris Agreement does not define particular emissions allocation processes for developed, developing, and least-developed parties to the agreement. However the countries agreed on the principle of equity and common but differentiated responsibilities (CBDR) and respective capabilities, in the light of different national circumstances. In this regard, developing countries, such as South Africa, should have an opportunity to allow for economic growth at lower decarbonisation rates than developed counterparts.

- South Africa's need to increase emissions in the short-term to achieve developmental goals: Industry and industrial development are significant drivers of national economic development. In this regard South Africa's Nationally Determined Contribution (NDC) submitted in Paris in 2015 sets out the national emissions trajectory up to 2050. South Africa's emissions are expected to peak between 2020 and 2025, plateau for approximately a decade and decline in absolute terms thereafter. This trajectory allows room for growth, and related carbon emissions, in order to address socio-economic developmental needs within a carbon-constrained context.

The impacts of climate change are diverse and far-reaching and will have an impact on the core operations, the value chain, as well as the social and natural environments associated with the proposed West Wits mine. However, this project is located in a unique context. The project falls within an existing and built-up urban environment. These areas are faced by a myriad of environmental and related social health concerns as a result of legacy mining issues in the area such as unmanaged tailings facilities. The West Wits project could play a critical role in addressing these issues, and as such contributing to building resilience in local communities specifically with regards to issues such as exposure to dust and historic water pollution.

In addition, this specialist assessment has provided mitigation and adaptation measures which build on the existing best practice design parameters to improve, monitor and communicate climate change mitigation and adaptation actions and objectives relevant to the West Wits mine. Importantly, mitigation and adaptation can only be commenced and fully integrated once the m is operational. Continuous monitoring and verification will allow for data flows to inform practical and appropriate mitigation and adaptation measures.

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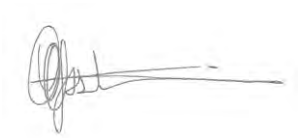
Declaration of Independence

Robbie Louw and Karien Erasmus as the authors of this report do hereby declare their independence as consultants appointed by SLR Consulting to undertake a climate change impact assessment for the West Wits Mining Project. Other than fair remuneration for the work performed, the specialists have no personal, financial business or other interests in the project activity. The objectivity of the specialists is not compromised by any circumstances and the views expressed within the report are their own.

Robbie Louw

Karien Erasmus

Dr. Claudia Kitsikopoulos



Roelof van Huyssteen

Details of Specialist

Promethium Carbon

Promethium Carbon is a South African climate change and carbon advisory company based in Johannesburg. With a view to making a difference in climate change in Africa and a focus on technical expertise, our team of climate change professionals assists businesses, ranging from small enterprises to multinational entities, on their journey towards a low carbon economy. We also assist governments and government institutions in planning for the imminent global carbon-constrained environment. Through our participation on various working groups and standards boards, we have established ourselves as knowledge leaders in the climate space and act as trusted advisors to our clients.

Promethium Carbon has conducted several climate change impact studies. These studies typically include an estimation of the carbon footprint of the activity or group of activities, as well as the vulnerability of the activity/ies to climate change. Promethium Carbon has been conducting climate change risk and vulnerability assessments as part of the Carbon Disclosure Project since 2008. In addition to this work, Promethium Carbon has also conducted standalone, detailed climate change risk and vulnerability assessments. These standalone assessments include thorough analysis of historical and projected weather data specific to the region in which the client operates. Promethium Carbon's assessment of vulnerability goes beyond core operations to include impacts within the supply chain and broader network of the client.

Robbie Louw

Robbie is the founder and director of Promethium Carbon. He has over 15 years of experience in the climate change industry. His experience (35 years) includes research and development activities as well as project, operational and management responsibilities in the chemical, mining, minerals process and energy fields. Robbie's experience in climate change includes (but is not limited) to:

- Climate change risk and vulnerability assessments: He has conducted assessments with large mining houses.
- Carbon footprinting: He has extensive experience in carbon footprinting. The team under his leadership has performed carbon footprint calculations for major international corporations operating complex businesses in multiple jurisdictions and on multiple continents.
- Climate strategy development: He has developed carbon and climate change strategies for major international corporations.
- Climate change impact and risk assessments: He has developed climate change risk assessments for various companies and projects.

- Climate change scenario planning: He has assisted a number of companies in climate change scenario analysis in terms of the recommendations of the Taskforce on Climate related Financial Disclosure (TCFD).

Karien Erasmus

Karien is a principal climate change advisor at Promethium Carbon and holds an Honours Degree in Sustainable Development. She is currently completing her MPhil in Development Practice, focusing on the 17 Sustainable Development Goals. Her additional postgraduate qualifications include diplomas in: Project management, community development and mine closure and ecological rehabilitation. She has been involved in the sustainability and climate change industry for the past 13 years, working extensively in Africa and on strategic local projects such as the Gautrain and the Bus Rapid Transit system in Johannesburg. Karien joined Promethium Carbon in 2015, and utilises her developmental background to inform the social context of various climate change and low carbon development projects. Over the past three years Karien has worked extensively within the mining sector. Karien's experience in climate change includes:

- Climate change risk and vulnerability assessments;
- Climate change impact assessments as part of the Environmental Authorisation process;
- Drafting CDP Climate Change and Water responses;
- Assessment of climate change and energy related regulations;
- Developing the land, community and energy nexus concept which links land rehabilitation to community upliftment through sustainable energy projects.

Dr. Claudia Kitsikopoulos

Claudia is a climate change advisor at Promethium Carbon and holds a Ph.D. in environmental risk management studies with a focus on climate change. She joined Promethium in 2018 and has a firm understanding of climate change drivers, interactions as well as mitigation and adaptation measures in the context of both ecology and business. Claudia has been working on projects related to carbon footprints, socio-economic impact assessment, environmental sustainability strategy development, climate change assessments and assisting in the preparation of science-based target report.

Roelof van Huyssteen

Roelof van Huyssteen, is an admitted attorney of the High Court of South Africa, and has been employed as a Climate Change Advisor with Promethium Carbon since 2018. Prior to joining Promethium, he worked as a practicing attorney in commercial law, environmental law and litigation. Having a keen interest in climate change and sustainable development he decided to pursue a career outside of a legal practice. Subsequently, Roelof enrolled to pursue his doctorate in laws in order to broaden his knowledge within the field of renewable energy regulation being a fundamental mechanism to mitigate and adapt to climate change. With an academic background within the field of carbon markets, Roelof has a firm understanding of green commodities and sustainable development within the corporate sphere. His understanding of both international and domestic legal frameworks pertaining to carbon trading has provided him with the ability to analyse the functioning of climate change law from a corporate perspective.

List of Acronyms

Abbreviation	Definition
COJ	City of Johannesburg
COP	Conference of the Parties
DMR	Department of Mineral Resources
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
FEPA	Freshwater Ecosystem Priority Areas
GHG	Greenhouse Gases
INDC	Intended Nationally Determined Contribution
IRP	Integrated Resource Plan
LHWP	Lesotho Highlands Water Project
LTAS	Long Term Adaptation Scenarios
MPRDA	Mineral and Petroleum Resources Development Act
NDC	Nationally Determined Contribution
NEMA	National Environmental Management Act
NEM:WA	National Environmental Management: Waste Act
NFEPA	National Freshwater Ecosystem Priority Areas
PPD	Peak Plateau Decline
ROM	Run of Mine
TNC	Third National Communication

NEMA Regulations (2014) (as amended) - Appendix 6

NEMA Regulations (2014) (as amended) - Appendix 6	Relevant section in this report
Details of the specialist who prepared the report	**Page 8, Details of Specialist**
The expertise of that person to compile a specialist report including a curriculum vitae	**Page 8, Details of Specialist and Appendix A: Specialist CVs**
A declaration that the person is independent in a form as may be specified by the competent authority	**Page 7, Declaration of Independence**
An indication of the scope of, and the purpose for which, the report was prepared	**Chapter 2: Project Scope**
An indication of the quality and age of base data used for the specialist report	**Chapter 4 – Section 4.3: Data used in the preparation of specialist report**
The duration date and season of the site investigation and the relevance of the season to the outcome of the assessment	**Not applicable to climate change impact assessment**
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	**Chapter 4: Methodology**
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternatives	**Not applicable to climate change impact assessment**
An identification of any areas to be avoided, including buffers	**Not applicable to climate change impact assessment**
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	**Not applicable to climate change impact assessment**
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	**Chapter 5 and Chapter 6**
Any mitigation measures for inclusion in the EMPr	**Chapter 7: Options for Climate Change Mitigation**
Any conditions for inclusion in the environmental authorisation	**Chapter 7 and Chapter 8**
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	**Chapter 7**
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and regarding the acceptability of the proposed activity or activities	**Chapter 9: Specialist opinion**
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	**Chapter 7: Options for Climate Change Mitigation** **Chapter 8: Options for Climate Change Adaptation**
A description of any consultation process that was undertaken during the course of preparing the specialist report	**Not applicable to climate change impact assessment**
A summary and copies of any comments received during any consultation process and where applicable all responses thereto	**Not applicable to climate change impact assessment**

1 Introduction

West Wits MLY (Pty) Ltd. has applied for a mining right in terms of the Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA) as amended, for gold, uranium and silver over various portions of farms. The proposed establishment of the West Wits Mining Project is located within the City of Johannesburg, to south of Roodepoort and the north of Soweto. The project would involve the development of five open pit mining areas and refurbishment of two existing infrastructure complexes. The re-mining of the area could potentially assist in mitigating negative legacy mining impacts in the area and as a result addressing historical spatial discontinuity between the northern and southern parts of Johannesburg in the long-term.

In accordance with the relevant regulations, an Environmental Impact Assessment process must be completed before project development can proceed. As part of the Environmental Impact Assessment, Promethium Carbon has been appointed to undertake a specialist climate change assessment of the proposed project. This involves assessing the project's prospective contribution to climate change through the emission of greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) as well as determining the risks and vulnerabilities faced by the project as a result of climate change. This assessment covers the mining project's core operation, value chain and social as well as natural environment.

The mining project's contribution to global climate change is determined by the greenhouse gas emissions produced by the mine and its value chain. This assessment focuses on calculating the greenhouse gas emissions and investigating the consequent climate change impacts through the value chain.

The global nature of climate change impacts is such that the greenhouse gas emissions from any individual project or source cannot be connected directly to any specific environmental impacts as a consequence of climate change. The analysis presented in this report is presented in the context that, even though the individual GHG emission contribution of a project cannot be directly linked to specific localised climate change impacts, global climate change is nevertheless significant and can be quantified as such. In other words, the specific greenhouse gas emissions from the mining project cannot be attributed directly to any particular climate change effects. Despite this there is a collective responsibility to address the global challenge of climate change and each actor, such as the proposed West Wits mining project, has an individual responsibility to minimise its contribution to climate change and managing climate related risks within its area of influence.

The analysis presented in this report is aligned with the principles of the National Environmental Management Act, 1998 (Act No 107 of 1998) as it seeks to provide the project developer with the best possible information to evaluate the project's environmental sustainability in terms of climate change.

The broad terms of reference and scope of work for this specialist climate change assessment include the following:

1. Calculating the construction and operational greenhouse gas emissions of the project.
2. Reviewing the greenhouse gas emissions mitigation options for the project.
3. Conducting an impact assessment of the project by:
    a) Considering its contribution to the South African national emissions inventory, the global greenhouse gas inventory, and the potential impacts of the project on the onset of global anthropogenic climate change;
    b) Comparing the emissions associated with the value chain of the project against the current South African baseline with consideration of impacts on the future baseline; and
    c) Exploring the potential impacts of global climate change on the risks faced by the project and the project's value chain, as well as the natural and social context of the project.
4. Assessing requirements for greenhouse gas emission management activities for the mine's operations.

Note that the analysis does not include the calculation of the construction and operational greenhouse gas emissions of the project alternatives, as the mining project is dependent on the location of the resource to be mined, therefore no alternative site (proposed mining right application area) was considered.

2 Project Scope

2.1 Project description

West Wits MLI (Pty) Ltd (hereafter West Wits) has applied for an environmental authorisation to the Department of Mineral Resources (DMR) to establish a mining operation. The proposed mining activities will be located in the south of Roodepoort and in the north of Soweto, in the City of Johannesburg Metropolitan Municipality, Gauteng.

West Wits has applied for a mining right for gold, uranium and silver over various portions of farms, in terms of the Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA) as amended. An Environmental Impact Assessment (EIA) regulatory process must be conducted prior to project commencement in line with the MPRDA, 2002 (Act 28 of 2002), the National Environmental Management Act, 1998 (No. 107 of 1998) (NEMA) and the National Environmental Management: Waste Act, 2008 (No. 59 of 2008) (NEM:WA), all as amended.

In broad terms the proposed project would involve the development of five open pit mining areas:

- Mona Lisa Bird Reef Pit;
- Roodepoort Main Reef Pit;
- Rugby Club Main Reef Pit;
- 11 Shaft Main Reef Pit; and
- Kimberley Reef East Pit.

In addition, the project will include the refurbishment of two existing infrastructure complexes, referred to as the Bird Reef Central Infrastructure Complex and Kimberley Reef East Infrastructure Complex, to access the existing underground mine workings.

The project would also involve the establishment of run of mine (ROM) ore stockpiles, waste rock dumps and topsoil stockpiles. Various supporting infrastructure such as material storage, general and hazardous waste as well as sewage and water management facilities, offices and workshops would also be required.

The construction phase will take approximately three years, open pit mining and concurrent rehabilitation operations for three to five years (including rehabilitation). The life of mine of the proposed Kimberley Reef East underground workings is 20 years, and 10 years for the Bird Reef Central underground workings. Mining will be done in a phased approach where each pit will be mined for approximately five to nine months, including rehabilitation. Opencast mining activities will run for 12 hours a day for five days a week and for eight hours one additional day a week. The construction activities of surface infrastructure for the underground operations will run for

10 hours a day for five days and seven hours on one additional day a week. Underground mining activities will run 24 hours a day for seven days a week.

The main commodity to be mined is gold. Uranium and silver can be extracted as by-products. Ore will be crushed on site prior to transportation off-site. The crushed ROM would be transported to and processed at an existing off-site plant. The amount of mineable resource over the mine's lifespan is estimated to be 9 Million tonnes.

In accordance with the relevant regulations, an Environmental Impact Assessment process must be completed before project development can proceed. As part of the Environmental Impact Assessment, Promethium Carbon has been appointed to undertake a specialist climate change assessment of the project. This involves assessing the project's prospective contribution to climate change through the emission of greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) as well as the impact of climate change on the mine's core operation, value chain and social as well as natural environment.

2.2 Summary of potential project impacts

Potential project impacts that have been identified during the scoping phase relate to the natural environment, for example loss of soil and land capability through contamination, physical loss and/or general disturbance of terrestrial biodiversity, loss or disturbance of aquatic ecosystems and reduction in surface water quantity and quality affecting third party users (radiation and non-radiation). Negative visual impacts, decrease in air quality from project emissions (radiation and non-radiation), increase in noise levels, ionizing radiation, effects on roads due to project related traffic, impact on surrounding land uses (including valuation statement), blasting and vibration related impacts (air blasts, ground vibration and fly rock) as well as human health risks, loss of or damage to heritage and/or paleontological resources are potential cultural and socio-economic impacts resulting from the proposed West Wits Mining Project.

3 Climate change context

3.1 Global Context

Anthropogenic climate change as a global phenomenon is caused by the accumulated greenhouse gas emissions from global emitting sources. The impact thereof on society is increasingly of concern. In 2013, CO_2 levels surpassed 400 parts per million (ppm) for the first time in recorded history[2]. Various scenarios have been developed to model both mitigated (reducing emissions) and unmitigated (business as usual) options.

The receiving environment for this project, in the context of climate change, is the global atmosphere. The duration of the impact of the greenhouse gas emissions is considered as effectively permanent as the greenhouse gas emissions produced remain in the atmosphere for a long time.

The global nature of climate change impacts is such that the greenhouse gas emissions from any individual project or source cannot be connected directly to any specific environmental impacts as a consequence of climate change. The analysis presented in this report is presented in the context that, even though the individual GHG emission contribution of a project cannot be directly linked to specific localised climate change impacts, global climate change is nevertheless significant and can be quantified as such. In other words, the specific greenhouse gas emissions from the West Wits mine cannot be attributed directly to any particular climate change effects. Despite this there is a collective responsibility to address the global challenge of climate change and each actor, such as the proposed West Wits mining project, has an individual responsibility to minimise its own negative contribution to climate change.

3.2 Local Context

South Africa's Nationally Determined Contribution (NDC) submitted in Paris in 2015 sets out a national emissions trajectory up to 2050. South Africa's emissions are expected to peak between 2020 and 2025, plateau for approximately a decade and decline in absolute terms thereafter ("Peak, Plateau and Decline trajectory", PPD). South Africa, as a developing nation, requires some allowances to increase its emissions in the short-term to foster economic growth and steadily transition towards a low carbon economy. South Africa is therefore not limiting itself to specific emissions numbers, but the NDC rather provides a PPD trajectory range from 2016 (reference point) to 2050. The country's lower boundary PPD pledge is set at 398 Mt CO_2e and the upper PPD boundary at 614 MtCO_2e for the years 2025 to 2030.

The amount of greenhouse gas that South Africa can emit in terms of the NDC is the country's "carbon budget". Calculations done by the IPCC[3] show that the world as a whole can emit 1,010 gigatons of CO_2e (from 2012) if the effect of climate change is to be limited to a 2°C temperature increase. For a 1.5°C temperature increase, this amount is reduced to 360 gigatons

[2] NASA. 2019. Graphic: The relentless rise of carbon dioxide (https://climate.nasa.gov/climate_resources/24/). Accessed 19 February 2019.

[3] IPCCC AR5 Synthesis Report, https://www.ipcc.ch/report/ar5/syr/

of CO_2e. This carbon budget forms one of the planetary boundaries[4] that should not be exceeded in terms of sustainability principles.

In addition to the NDC, Figure 1 below outlines the carbon dioxide emissions constraint considered in the base case of the draft Integrated Resource Plan (IRP) Update from November 2016[5]. In line with government policy to reduce greenhouse gas emissions, the IRP update applies the moderate decline annual constraints as an instrument to reduce national emissions. This might change in the future in line with the Department of Environmental Affairs mitigation system and proposed Climate Change Act.

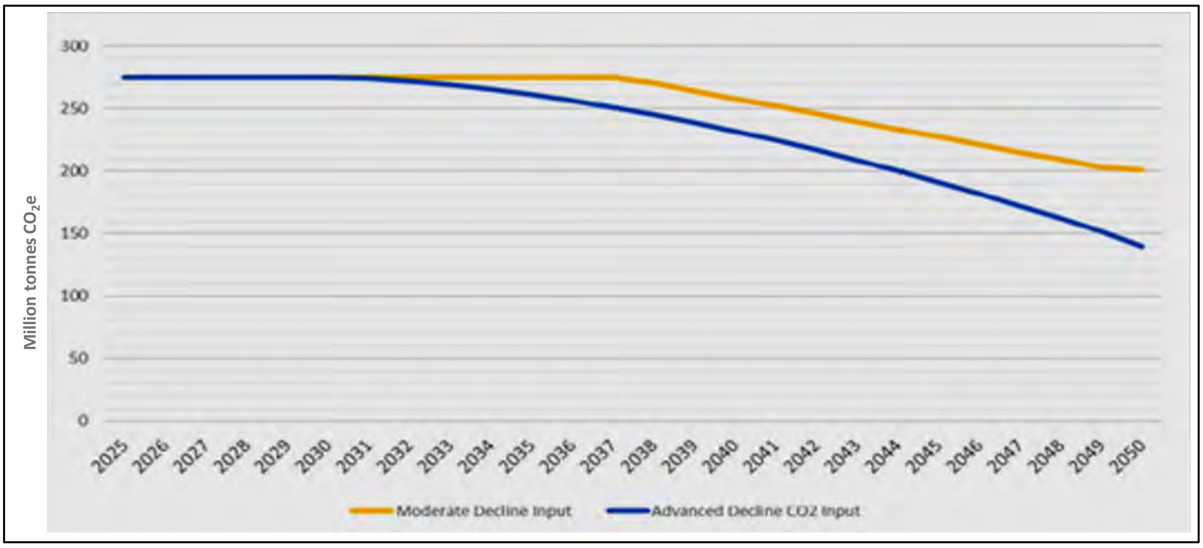


Figure 1: South Africa's Integrated Resource Plan (IRP) emission trajectories

The climate change impact assessment is done in the context that any project that emit greenhouse gas emissions consume a portion of South Africa's carbon budget, which is a limited resource. The impact of the project should therefore be seen in the context of how much of this limited resource the project consumes.

Despite the global and national commitment to limiting global temperature increase to 2°C, the NDCs of all countries combined cover only approximately one third of the emission reductions needed to achieve this goal. Therefore, whether the NDCs will be implemented by the global community or not; there will be significant climate change impacts affecting South Africa, and

4 Stockholm Resilience Centre. 2018. A reference point for research on global sustainability (https://www.stockholmresilience.org). Accessed 10 October 2018.

5 DoE. 2016. Integrated Resource Plan Update Assumptions, Base Case Results and Observations (http://www.energy.gov.za/IRP/2016/Draft-IRP-2016-Assumptions-Base-Case-and-Observations-Revision1.pdf). Accessed 17 October 2018. Department of Energy, Pretoria, South Africa. *Later versions of this report do not have data that allows for the trajectory to be calculated.*

thus the West Wits project as well. As a consequence, while the impact of West Wits on climate change may be small, the impacts of climate change on the West Wits project could potentially be large.

Risks resulting from climate change impacts such as increasing land-surface temperatures, increasing rainfall variability, decreasing overall rainfall, as well as increasing frequency and intensity of extreme weather events relate to:

- Decreasing water availability and quality may negatively affect direct operations as well as the upstream and downstream value chain
- Damages to infrastructure can disrupt operations, transport of goods and lead to increased risk of injury
- Labour productivity decrease due to excessive heat exposure
- Health of employees may be compromised due to rising food insecurity and an increased number of casualties as a result of heat effects
- Declining air quality in cities or city regions may impact on the issuance or conditions of issuance of the air quality license
- Disruption to commerce, critical infrastructure and developments, transport systems and traffic by extreme rainfall events and flooding could impact on the West Wits project's ability to operate
- This also leads to increased number of power outages, water supply and transport disruptions
- Increased risk of infectious, respiratory and skin diseases, water- and food-borne diseases

The focus of managing climate change should therefore not be limited to emissions reductions (mitigation), but more importantly focus on adaptation measures as well. Identifying impacts of climate change on the project will therefore be considered in this assessment, which can inform West Wits project's design and implementation strategies to reduce risk exposure and ensure long-term sustainability.

3.3 Observed Trends and Projected Climate Change

3.3.1 National overview

The impacts of climate change on South Africa have been summarised in the *Long Term Adaptation Scenarios* (LTAS) study which was executed by the Department of Environmental Affairs in 2012. However, significant progress has been made in South Africa since the LTAS in terms of the local generation of detailed regional climate futures for the country. The most recent modelling was conducted for South Africa's *Third National Communication*[6] (TNC). Some of the salient points from the LTAS, which are still relevant, are:

- Air temperatures in South Africa have increased at least 50% more than the global annual average of 0.65 °C over the last five decades. The Intergovernmental Panel on Climate Change (IPCC) found in its fifth assessment report that it is "likely that land temperatures over Africa will rise faster than the global land average, particularly in the more arid regions, and that the rate of increase in minimum temperatures will exceed that of maximum temperatures."[7] This indicates that in a world of more than 2°C average temperature change, South Africa could experience changes of over 3°C.
- Sustained warming and increasing variability in rainfall over the short term (next decade) will have increasingly adverse effects on key sectors of South Africa's economy in the absence of effective adaptation responses. Early impacts will largely be felt by the poor and vulnerable groups in society. These societal groups are both more exposed and more sensitive to fluctuation weather patterns and climatic events such as droughts and floods. In addition, poverty and a lack of infrastructure or service provision erodes the adaptive capacity of these communities to climate change, rendering them increasingly vulnerable.

A key feature of the projected climate change futures of South Africa, as per the *Third National Communication,* is that temperatures are to increase drastically under low mitigation scenarios. For the far-future period of 2080-2099, temperature increases of more than 4 °C are likely over the entire South African interior, with increases of more than 6 °C plausible over large parts of the western, central and northern parts. Such increases will also be associated with drastic increases in the number of heat-wave days and very hot days, with potentially devastating impacts on agriculture, water security, biodiversity and human health.

Wetter conditions are projected for the central part of the country for the period 2015 – 2035 and 2040 – 2060. However far (2080 – 2099) future projections indicate general drying over the whole of South Africa. These rainfall changes can be seen in the Figure 2 below.

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6 DEA. 2017. *South Africa's Third National Communication under the United Nations Framework Convention on Climate Change*. Department of Environmental Affairs, Pretoria, South Africa.

7 IPCC. 2014. *Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. R.K. Pachauri and L.A. Meyer (eds.). Intergovernmental Panel on Climate Change, Geneva, Switzerland.

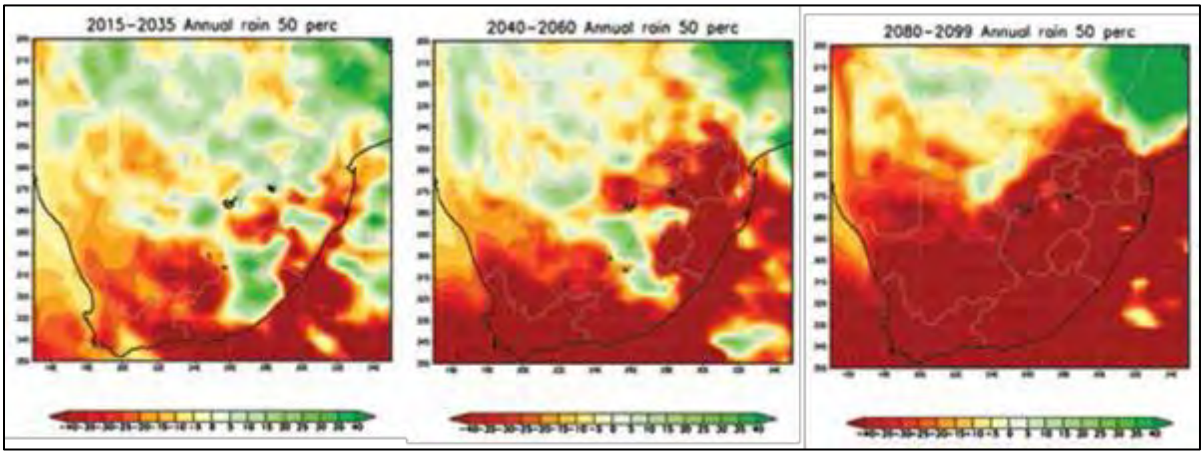

Figure 2: Projected change in the average annual rainfall (mm) over South Africa for the time periods 2015–2035; 2040–2060 and 2080–2100 relative to 1970–2005 under low mitigation[8]

The following section looks at climate on a provincial level, as relevant to the proposed West Wits Project.

3.3.2 Provincial overview

The proposed West Wits Project is situated in the west of Gauteng Province, to the south of Roodepoort and in the north of Soweto.

Gauteng is highly vulnerable to climate change[9]. The mean surface temperature has risen by more than 2°C per century[10]. The number of hot days has been increasing, while the number of cold days have been decreasing. Data further suggest that intense daily rainfall and extreme rainfall events are increasing in frequency. Thunderstorms with hail, damaging winds and flash floods may increase locally in intensity.

The updated modelling from the draft TNC indicates two possible narratives for the Gauteng province. The province may plausibly experience **a warmer future with reduced water security**, with high fire risk and a temperature increase predicted as large as 4-6°C (under low mitigation) or a warmer but water secure future with a temperature increase up to 4-6°C and extreme rainfall events (under high mitigation). This change in climatic parameters could also increase the frequency of occurrence of heat-wave days and high fire-danger days[10].

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[8] Department of Environmental Affairs. 2013. Long-Term Adaptation Scenarios Flagship Research Programme for South Africa. Climate Trends and Scenarios for South Africa. Department of Environmental Affairs, Pretoria, South Africa.

[9] Gauteng City Region Review. 2013. Regional Economy (http://2013.legacy.gcro.unomena.net/regional-economy). Accessed 12 February 2019.

[10] DEA. 2017. *South Africa's Draft Third National Communication under the United Nations Framework Convention on Climate Change*. Department of Environmental Affairs, Pretoria, South Africa.

The projected changes as a result of climate change in Gauteng are[11]:

- Current hazards:
  - Excessive rainfall and floods (which could exacerbate the sinkholes in dolomite areas);
  - Hailstorms;
  - Heat waves;
  - Fires;
  - Wind storms; and
  - Droughts.
- Projected changes in climate and extreme weather events:
  - Increase in average temperature by 2 °C in the near future;
  - Decrease in the number of days with frost;
  - Increase number of hot days (35 °C) +20 days;
  - Heat waves and fire danger;
  - Decrease in annual rainfall;
  - Increase in extreme weather events, thunderstorms, lightning, hail, flash;
  - floods and damaging winds;
  - Wet years less frequent; and
  - Dry years more frequent.

Water security and groundwater are considered as part of this specialist climate change impact assessment and considered from a regional perspective. This is due to the fact that water is a key resource that will be affected as a result of climate change. Prolonged periods of drought, increasing ambient temperatures and flash flooding impact water availability (e.g. groundwater sources or water recharge ability) on a regional scale.

The currently experienced and projected climatic changes will greatly impact on Gauteng's water supply and quality provision, which could in future constrain the province's economic growth. Increasing mean surface temperatures will lead to increased water temperatures, reducing water quality. This will also leads to increased evaporation, which reduces water availability. Not only need the water yield in the dams located within the province be preserved, but also the mega-dam region of south-eastern South Africa, from which 40% of Gauteng's rainfall is generated. This region is also expected to experience increased droughts.

It is within this context that this report suggests that, considering the regional climate risk associated with water, buffering mechanisms need to be considered in the development of the proposed West Wits Project to maintain water security.

[11] DST and CSIR. 2017. *Understanding the social and environmental implications of global change*. Department of Science and Technology, Pretoria, South Africa.

3.3.3 Metropolitan Municipal overview

The proposed West Wits Project falls within the City of Johannesburg (CoJ) Metropolitan Municipality. The CoJ is the economic hub of southern Africa and South Africa and is one of the 40 largest metropoles globally (C40 cities).

An overall warming trend, especially in the winter minimum night-time temperature (up to 1°C), was observed in the municipality since the mid-1960s. The climate is predicted to become significantly hotter and more humid, rainfall may increase in frequency and intensity and the wet season could commence earlier in the spring and finish in late autumn.[12] Frost days (temperature drops below 0°C) will become rare, while the number of hot days (above 30°C) may account for up to 30% of summer days and up to 50% of all spring days.[12] Key climate change risks were identified as part of the Metropolitan Municipality's climate change adaptation plan (Table 3). The main identified climate change risks for the CoJ are heat waves, floods and water scarcity. The CoJ was predicted to experience significant water shortage by 2019.

Table 1: City of Johannesburg Metropolitan Municipality key climate change risks[12,13,14]

Risk	Risk Title	Likelihood	Magnitude
Biodiversity and Environment	Biodiversity impacts on disease vectors	Low-medium	Medium-high
Human Health	Increase in heat-related deaths	Medium-high	Medium-high
Human Settlements, Infrastructure and Disaster Management	Increased risk of urban flooding	Medium-high	High
Human Settlements, Infrastructure and Disaster Management	Climate change-driven refugees and migrants	Low-medium	Medium-high
Water	Water scarcity caused by droughts, growing demand and fixed/declining natural supply as well as disruption to internal and external water security	Medium-high	Medium-high

12 CoJ. 2009. Climate Change Adaptation Plan. City of Joburg, Johannesburg, South Africa.
13 City of Johannesburg. 2017. Joburg 2014 Growth and Development Strategy. City of Johannesburg, Johannesburg, South Africa.
14 City of Johannesburg. 2011. 2017/18 Integrated Development Plan Review. City of Johannesburg, Johannesburg, South Africa.

Although the CoJ's exposure to climate change related impacts is relatively limited and rated fourth best placed city (out of 21 major cities in Africa, Asia and Middle East) due to its location and not being exposed to natural disasters such as typhoons or hurricanes, climate change impacts still have the potential to be significant. Firstly, several systems within the city, such as storm water, water and energy infrastructure, are strained under existing climate conditions. Urbanisation, blocked sewers and ageing infrastructure also negatively impact on surface water quality in the city region. Further climatic changes as outlined above will exacerbate the problems. Secondly, the city will be affected by climate change impacts outside its geographical boundaries. This relates to migration, water and food security.[15] Climate change is also projected to have negative impacts on air quality in the Metropolitan Municipality, in which poor air quality is already an existing issue (refer to Section 3.3.5).

3.3.4 Rainfall

The West Wits Project falls within the Upper Vaal water management area. The Municipality, its residents, the industry and agricultural sector, as well as South Africa as a country, are highly dependent on the Vaal River for water provision. Rainfall projections for the Vaal Hydrological Zone show high levels of uncertainty. Two climate scenarios project a decrease in precipitation in spring, summer and autumn, while two others suggest an increase in spring and summer rainfall. However, considering the variability in rainfall in conjunction with other climatic factors such as increased temperatures and prolonged dry periods, drier conditions and related risks must be considered. It must be stressed that for the purposes of this report, rainfall variability and linked water risks are relevant from a regional perspective due to the scale and nature of climate change impacts.

The two most significant climate change projections in the CoJ are increases in both average temperatures and rainfall variability. Gauteng as well as the CoJ require more water than the rivers within the provincial boundaries can provide. Water demand will increase due to rising temperatures and a rising population due to migration. The water demand is currently met by transferring water from Lesotho (Lesotho Highlands Water Project; LWHP) to the Vaal tributaries.[15] The CoJ is therefore more vulnerable to climate change impacts on rainfall patterns in the Lesotho region without which the Municipality and the Gauteng Province are unable to meet water demands, than on the local and any other region in South Africa. The risk of water shortage increases during drought conditions and during times when supply from local sources is restricted. Although now in-depth studies for the impacts of climate change on rainfall variability and thus water availability for the Lesotho region is available, high-level findings suggest that the climatic trends are similar to the ones of the CoJ.[16]

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[15] CoJ. 2009. Climate Change Adaptation Plan. City of Joburg, Johannesburg, South Africa.

Heavier and prolonged rainfall periods are predicted to aggravate existing water quality, storm water, sanitation as well as general infrastructure challenges. In addition, blockage of the sewage system infrastructure by littering transported by surface waters and electricity and waste water treatment facility failures due to flooding leading to sewage entering water courses will worsen existing bacterial infection risk, thus human health and aquatic biodiversity risks. Other impacts resulting from increased rainfall due to climatic changes relate to increased outbreaks of water-borne diseases due to sewage contamination and more favourable climate conditions for disease vectors (e.g. bilharzia), habitat and species loss from uncontrolled run-off, sediment build up in dams leading to increased maintenance costs, and erosion of river banks and channels. Damage to property, personal injury, impacts on livelihoods, increased road accidents and traffic congestions are also a likely result from urban flood risk.

These projections can impact *inter alia* the water availability and quality for the operations at the mining site. In conjunction with prolonged drought and a predicted increase in the frequency and intensity of severe weather events, reduced buffering capacity of severely impacted biomes and wetland areas and water contamination, flooding presents a major risk to the West Wits Project. Similarly, industrial infrastructure can be impacted, and thus reduce productivity and disrupt service delivery (e.g. water, electricity).

3.3.5 Temperature

Climate change projections for the province of Gauteng point towards increases in annual temperatures by at least 2°C in the next two decades (between 2015 and 2035) and higher increases over extended periods possibly reaching 4°C to 6°C increases in extreme scenarios. In the CoJ, temperatures are predicted to increases by 2.3°C by 2065 and 4.4°C by 2081-2100.[16] Although increasing temperatures are as result of climate change, and not a result of the proposed mining operations, temperature increases will impact the area in which the mining project will operate as well as its labour force as employees working outdoors will be particularly vulnerable to increases in temperature. Consequently, the rising temperatures may pose health hazards and reduce labour productivity. The water demand will increase with rising temperatures. Gauteng and the CoJ will be facing water provision challenges in the future. This can impact the water availability for the operations at the mining sites as well as access to water for the nearby communities within the West Wits Project operates. A conflict of interest may arise when water allocations may need to be prioritised. Similarly, the energy demand will increase with rising temperatures (for cooling), which may put further strain on existing capacity and maintenance problems of the grid. Consequently, power outages may result and/or usage time allocation, both which would impact on the mining project's operations.

[16] CoJ. 2009. Climate Change Adaptation Plan. City of Joburg, Johannesburg, South Africa.

Rising surface temperatures can increase ground-level ozone concentration and a strengthening in inversion layers exacerbates smoke events. Labour would be at risk from a health perspective, and losses in productivity leading to economic losses may be a consequence of pollution-related illnesses.[16]

3.4 Other Potential Climate Change Dimensions Relevant to the West Wits Project

Other potential climate change risks are those that relate to climate change, but cannot be classified as physical or regulatory risks. These risks can include:

- Reputational risk, especially concerning negative perceptions of the general public or investors;
- Induced changes in human and cultural environments (for example, migration and cultural changes);
- Spatial pressures in terms of land rehabilitation and surrounding urban pressures;
- Increasing humanitarian demands, as climate change impacts are experienced.

South Africa, and the Gauteng Province, has an economically divided society due to a number of socio-economic disparities. As a result, its population is characterized by a vulnerable majority. The vulnerable majority is more exposed to climate change impacts and may pose risks to mining companies, either through migration of workforces or increased humanitarian demands.

4 Methodology

The following section provides an overview of the methodology applied in the climate change assessment related to the proposed West Wits Project. The methodology was informed by the nature of climate change, applicable timeframes with regards to both the project and long-term climate impacts, as well as risks and vulnerabilities applicable to the mine operations and the area in which they will operate.

4.1 Impact of the Project on Climate Change

The following subsections outline the methodology used to assess the impacts of the West Wits Project's GHG emissions. The results of the carbon footprint calculations and the assessment of the environmental impacts thereof are presented in section 5 of this report.

4.1.1 GHG emissions estimation methodology

The carbon footprints for both the construction and operational phases of the project presented in this assessment have been guided by the following reference documents:

- *ISO/SANS 14064 Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals* (Standards South Africa, 2006);
- The Greenhouse Gas Protocol's *A Corporate Accounting and Reporting Standard (Revised Edition)* (Greenhouse Gas Protocol, 2015); and
- The Department of Environmental Affairs' *Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry* (DEA, 2016).

The principles of the ISO/SANS 14064-1 standard have been applied to West Wits Project in the calculations of the future GHG emissions of the proposed project (Table 2).

Table 2: ISO/SANS 14064-1 principles for carbon footprints

Relevance	Selecting all the GHG sources, sinks, reservoirs, data and methodologies that are appropriate.
Completeness	Including all the GHG emissions and removals relevant to the proposed project.
Consistency	Enable meaningful comparisons to be made with other GHG related information.
Accuracy	Reducing bias and uncertainties as far as is practical.
Transparency	Disclosing sufficient and appropriate GHG related information to allow intended users to make decisions with reasonable confidence.

The following process was followed in the calculation of carbon footprint of the West Wits Project:

- Boundaries of the analysis were set;
- GHG sources inside the boundary were identified;
- Quantification method was established; and
- GHG emissions inventory was calculated.

4.1.2 Environmental impacts of GHG emissions

The analysis presented in this report is aligned with the principles of the National Environmental Management Act (NEMA), 1998 (Act No 107 of 1998) as it seeks to provide the project developer with the best possible information to evaluate the project's environmental sustainability.

The broad terms of reference and scope of work for this specialist climate change assessment include the following:

1. Calculating the construction and operational greenhouse gas emissions of the project.
2. Reviewing the greenhouse gas emissions mitigation options for the project.
3. Conducting an impact assessment of the project, its alternatives and mitigation options by:
    a) Considering its contribution to the South African national emissions inventory, the global greenhouse gas inventory, and the potential impacts of the project on the onset of global anthropogenic climate change;
    b) Comparing the emissions associated with the value chain of the project against the current South African baseline with consideration of impacts on the future baseline; and
    c) Exploring the potential impacts of global climate change on the risks faced by the project and the project's broader network.
4. Assessing requirements for greenhouse gas emission management activities for the West Wits Project operations.

Note that the analysis does not include the calculation of the construction and operational greenhouse gas emissions of the project alternatives, as no alternatives were provided by the project developer.

The Environmental Impact Assessment reporting requirements listed below set out the criteria to describe and assess an environmental impact. These criteria are used to assess the climate change impacts associated with the greenhouse gas emissions from the West Wits Project in terms of their contribution to the national greenhouse gas inventory.

Please note that these criteria were developed to assess local environmental impacts. As climate change is a global phenomenon, the criteria are not fully applicable, but they are the best tool to work with, and are therefore used in this assessment. The authors of this report have amended the quantification of Magnitude (M) in the table below in order to align the methodology with global impact.

Table 3: Environmental Impact Assessment Criteria

Nature	A description of what causes the effect, what will be affected and how it will be affected. In the case of climate change assessments, the nature of the impact is the contribution of the project to global anthropogenic climate change, and the utilisation of a part of South Africa's carbon budget, as articulated in the country's Nationally Determined Contribution (NDC) in terms of the Paris Agreement.

<table>
<tr><td>Extent (E)</td><td>An indication of whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high).

In the case of climate change assessments, the extent is always global, and thus a 5 is allocated to all projects that contribute to global anthropogenic climate change.</td></tr>
<tr><td>Duration (D)</td><td>An indication of the lifetime of the impact quantified on a scale from 1-5. Impacts with durations that are; very short (0–1 years) are assigned a score of 1, short (2-5 years) are assigned a score of 2, medium-term (5–15 years) are assigned a score of 3, long term (> 15 years) are assigned a score of 4 or permanent are assigned a score of 5.

In the case of climate change assessments, the duration is always long term, and thus a 5 is allocated to all projects that contribute to global anthropogenic climate change.</td></tr>
<tr><td>Magnitude (M)</td><td>An indication of the consequences of the effect quantified on a scale from 0-10. A score of 0 implies the impact is small, 2 is minor, 4 is low and will cause a slight impact, 6 is moderate, 8 is high with sizable changes, and 10 is very high resulting drastic changes.

The context within which the EIA reporting requirements were developed to describe and assess environmental impacts, have yet to be applied to greenhouse gas emissions that have a global impact. For this reason, a materiality threshold was defined.

The IPCC's Fifth Assessment Report (IPCC, 2014) indicates that the world can emit 1,010 gigatons of CO_2e if the effect of climate change is to be limited to a 2°C temperature increase. This figure is the global carbon budget. South Africa's share of this global budget is calculated based on the national population figure of 58 million people (Stats SA, 2018) as a percentage of the global population of 7.7 billion people (Worldometers, 2019). South Africa's carbon budget in this respect is therefore approximately 7,572 Mt CO_2e. The following impact ratings have been identified as a means of benchmarking GHG inventories, over the lifetime of the specific activity/ies, related to emissions that occur within the boundaries of South Africa.

Table 4: Greenhouse gas emissions impact rating
<table>
<tr><th></th><th>GHG inventory</th><th>% of South African carbon budget</th></tr>
<tr><td>South Africa's carbon budget based on proportion of local population</td><td>7,572 $MtCO_2e$</td><td></td></tr>
</table></td></tr>
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<table>
<tr><td></td><td>
<table>
<tr><td>Low impact by project – emissions up to:</td><td>10,000 tCO_2e</td><td>0.00013%</td></tr>
<tr><td>Medium: impact by project – emissions up to:</td><td>1,000,000 tCO_2e</td><td>0.013%</td></tr>
<tr><td>High: impact by project – emissions up to:</td><td>10,000,000 tCO_2e</td><td>0.13%</td></tr>
</table>
The calculated GHG inventory is assessed in terms of the quantity of the emissions allocated under the South African carbon budget that the activity/ies would use-up over the project lifetime.

The magnitude of a project is considered high if the emissions are equivalent to 0.13% of the South African carbon budget and low if they fall below 0.00013% of the South African carbon budget.</td></tr>
<tr><td>Probability (P)</td><td>An indication of the likelihood of the impact actually occurring estimated on a scale of 1–5. A score of 1 implies that the impact is very improbable, 2 are improbable, 3 are probable, 4 are highly probable and 5 are definite with the impact occurring regardless of any prevention measures.

The IPCC has reported that it is 95 percent certain that man-made emissions are the main cause of current observed climate change. Thus a value of 5 is allocated to all projects that contribute to global anthropogenic climate change.</td></tr>
<tr><td>Significance (S)</td><td>A weighting based on a synthesis of the characteristics described above and can be assessed as low (< 30 points), medium (30-60 points) or high (> 60 points). The significance points are calculated as: S = (E + D + M) x P.</td></tr>
</table>

The status of the impact will be described as positive, negative or neutral. Additional details will also be provided on the degree to which the impact can be reversed and the degree to which the impact may cause irreplaceable loss of resources. The extent to which the impact can be mitigated will also be highlighted.

4.1.3 Setting the boundaries of the greenhouse gas calculation

The boundaries for this climate change impact analysis are set in terms of SANS 14064 part 1. The emissions calculations for the West Wits Project construction and operation are applied based on the control approach. With this approach, the emissions are considered from all the facilities, sites, or operations that are controlled by the project owner, within the boundary of the facility.

The setting of operational boundaries is a two-step process:

Step 1: Identification of the emissions associated with the company's business operation.

Step 2: Classification of the emissions into three categories. These three categories are defined according to *ISO 14064 Part 1* as direct GHG emissions, energy indirect

GHG emissions, and other indirect GHG emissions, but are commonly referred to by The Greenhouse Gas Protocol as Scope 1, Scope 2, and Scope 3 emissions.

Direct GHG emissions are emissions from sources that will be owned or controlled by the owner of the proposed West Wits Project. Energy indirect GHG emissions are emissions resulting from imported electricity consumed by the mine. Other indirect GHG emissions are the emissions (excluding energy indirect GHG emissions) that occur because of owner's activities at the mine, but occur at sources owned or controlled by another company. According to the Greenhouse Gas Protocol, other indirect GHG emissions can be classified into two different categories also graphically presented in Figure 3 below:

- Upstream indirect GHG emissions (related to purchased or acquired goods and services); and;
- Downstream indirect GHG emissions (related to sold goods and services).

Figure 3 illustrates the different sources of emissions, as well as the operational boundaries of an organisation. The figure gives a breakdown of the various scopes, including examples of emissions associated to each scope.

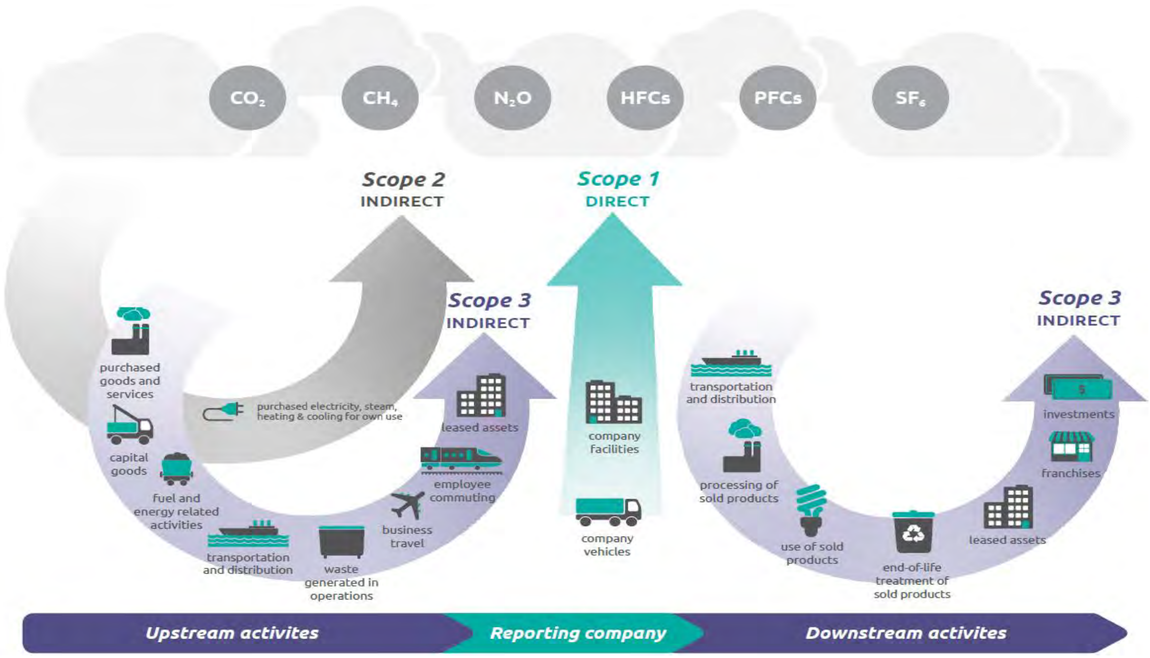

Figure 3: Illustration of different sources of emissions[17]

[17] The Greenhouse Gas Protocol: Corporate Value Chain Accounting and Reporting Standard

The carbon footprint presented in this study accounts for the direct and indirect operational emissions from the mining, as well as the direct and indirect construction emissions.

4.1.4 Identification of greenhouse gas sources

The identification of greenhouse gas sources is a detailed process. This is to ensure that all significant emission sources are identified for the carbon footprint calculation. The ISO 14064 Part 1 Standard and The Greenhouse Gas Protocol's 'A Corporate Accounting and Reporting Standard (Revised Edition)' and Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard was applied in addition to identify and quantify emission sources.

The following sources were identified for the proposed West Wits Project:

- **Scope 1 (Direct Emissions):**
    - Emissions from the combustion of diesel in stationary equipment;
    - Emissions from the combustion of diesel in mobile equipment/vehicles.
- **Scope 2 (Energy Indirect Emissions):**
    - GHG emissions from the generation of imported electricity consumed by the West Wits Project;
- **Scope 3 (Other Indirect Emissions)**
    - Purchased goods and services (mobile diesel combusted by contractors, concrete, steel, rubber, water);
    - Capital goods (equipment fleet);
    - Other fuel and energy related activities (diesel and electricity);
    - Upstream transportation and distribution (concrete, steel, rubber);
    - Waste generated (Municipal waste, construction waste, hazardous waste and wastewater);
    - Downstream transportation and distribution (diesel);
    - Employee commuting;
    - Processing of sold products.

4.1.5 Emission Factors

It is important that the emission factors used in carbon footprint calculations are appropriate for the local context and relevant to the technology being assessed. Local emission factors, such as the grid emission factor, have been sourced from the reports of Eskom as it is the main electricity generator of the country.

Other recognised emission factors have also been sourced from the 2006 Intergovernmental Panel on Climate Change's Guidelines (IPCC).[18] The IPCC values used are consistent with South Africa's Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emission by Industry.[19] The latest emission factors from the UK's Department of Environment, Food and Rural Affairs (DEFRA, 2018) data sets were used where local or domestically approved emission factors were not available.

These emissions factors are presented in tonnes of carbon dioxide equivalent (tonne CO_2e) and consider the global warming potential of all emitted greenhouse gases including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

The emission factors (and other conversion factors) used in the calculation of the carbon footprints are presented in Table 5.
Table 5

Table 5: Emission factors

	Value	**Unit**	**Reference**
Direct (Scope 1) Emissions			
Diesel (Stationary)	0.0028	tonnes CO_2e per litre diesel	SA Technical Guidelines TG-2016.1
Diesel (Mobile)	0.0031	tonnes CO_2e per litre diesel	SA Technical Guidelines TG-2016.1
Indirect (Scope 2) Emissions			
South Africa Electricity Grid	0.91135	tCO_2e/MWh	Calculated by Promethium using inputs from the Eskom 2018 IAR
Other Indirect (Scope 3) Emissions			
3.1 Purchased Goods and Services			
Concrete	0.1318	tonnes CO_2e per tonne	DEFRA 2018
Steel	4.31	tonnes CO_2e per tonne	DEFRA 2018
Rubber	0.7312	tCO_2e/t rubber	DEFRA 2018. Assumed to be equivalent to re-used tyres
Water	0.0014	tCO_2e/ML	Rand water integrated annual report 2017
3.2 Capital Goods			
Metals	4.3053	tCO_2e/t metals	DEFRA 2018
3.3 Fuel and Energy related activities			
Diesel	0.0006256	tCO_2e/l diesel	DEFRA 2018
Electricity	0.0571190	tCO_2/MWh	Calculated by Promethium using inputs from the Eskom 2018 IAR
3.4 Upstream Transportation and Distribution			

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18 IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf). Accessed 7 February 2019.

19 DEA. 2017. *South Africa's Draft Third National Communication under the United Nations Framework Convention on Climate Change*. Department of Environmental Affairs, Pretoria, South Africa.

All Heavy Goods Vehicle (100% laden)	0.0000186	tCO_2e/t.km	DEFRA 2018
3.5 Waste generated in operations			
Municipal waste	1.01633	tCO_2e/t MSW landfilled	'Friedrich & Trois, 2013. - Current and future greenhouse gas (GHG) emissions from the management of municipal solid waste in the eThekwini Municipality e South Africa'.
Hazardous Waste	1.01633	tCO_2e/t	'Friedrich & Trois, 2013. - Current and future greenhouse gas (GHG) emissions from the management of municipal solid waste in the eThekwini Municipality e South Africa'.
Construction waste (average, closed-loop)	0.001	tCO_2e/t waste	DEFRA 2018
Wastewater treatment - septic systems	0.1000000	tCO_2e/person.yr	Evaluation of Greenhouse Gas emissions From Septic Systems
3.6 Employee Commuting			
Average car emission factor (petrol)	0.000184	tCO_2e/km	DEFRA 2017
Minibus taxi emission factor	0.0000242	tCO_2e/passenger. km	Toyota Quantum specifications
Local bus emission factor	0.0001201	tCO_2e/passenger. km	DEFRA 2018
3.7 Downstream Transportation and Distribution			
All Heavy Goods Vehicle (100% laden)	0.0000186	tCO_2e/t.km	DEFRA 2018
Diesel (100% mineral diesel) - WTT	0.0006256	tCO_2e/L	DEFRA 2018
3.8 Processing of goods sold			
South Africa Electricity Grid	0.91135	tCO_2e/MWh	Calculated by Promethium using inputs from the Eskom 2018 IAR
Other factors			
GWP (CH_4)	23	tCO_2e/tCH_4	SA Technical Guidelines TG-2016.1
GWP (N_2O)	296	tCO_2e/tN_2O	SA Technical Guidelines TG-2016.1
Calorific Value of Diesel	0.0000381	TJ/litre	SA Technical Guidelines TG-2016.1
Calorific Value of Petrol	0.0000342	TJ/litre	SA Technical Guidelines TG-2016.1
Density of concrete	2400	kg/m^3	https://hypertextbook.com/facts/1999/KatrinaJones.shtml
Density of CH4	0.00000067	Gg/m^3	SA Technical Guidelines TG-2016.1
Density of steel	7860	kg/m^3	https://hypertextbook.com/facts/2004/KarenSutherland.shtml
Density of rubber	1200	kg/m^3	https://www.engineeringtoolbox.com/density-solids-d_1265.html
Density of Municipal Waste	312	kg/m^3	Palanivel and Sulaiman (2014)
Gigagram to tonne	1000	t/Gigagram	https://www.engineeringtoolbox.com/density-solids-d_1265.html

4.2 Impacts of Climate Change on the Project

The potential impacts of climate change on the project were assessed through a climate change vulnerability assessment. The vulnerability assessment considered the climate change impacts faced by the mine during the construction and operational phases. Vulnerability relates to the degree to which a system is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of a number of variables, including the character, magnitude and rate of climate change, the variation to which a system is exposed, its sensitivity and its adaptive capacity.[20]

By identifying the levels of exposure, sensitivity, potential physical and transitional risks and adaptive capacity, it can be assessed whether and to what extent the mines core operations, value chain and broader social and natural environment are vulnerable to climate change. The following figure provides a schematic overview of the approach to the vulnerability assessment.

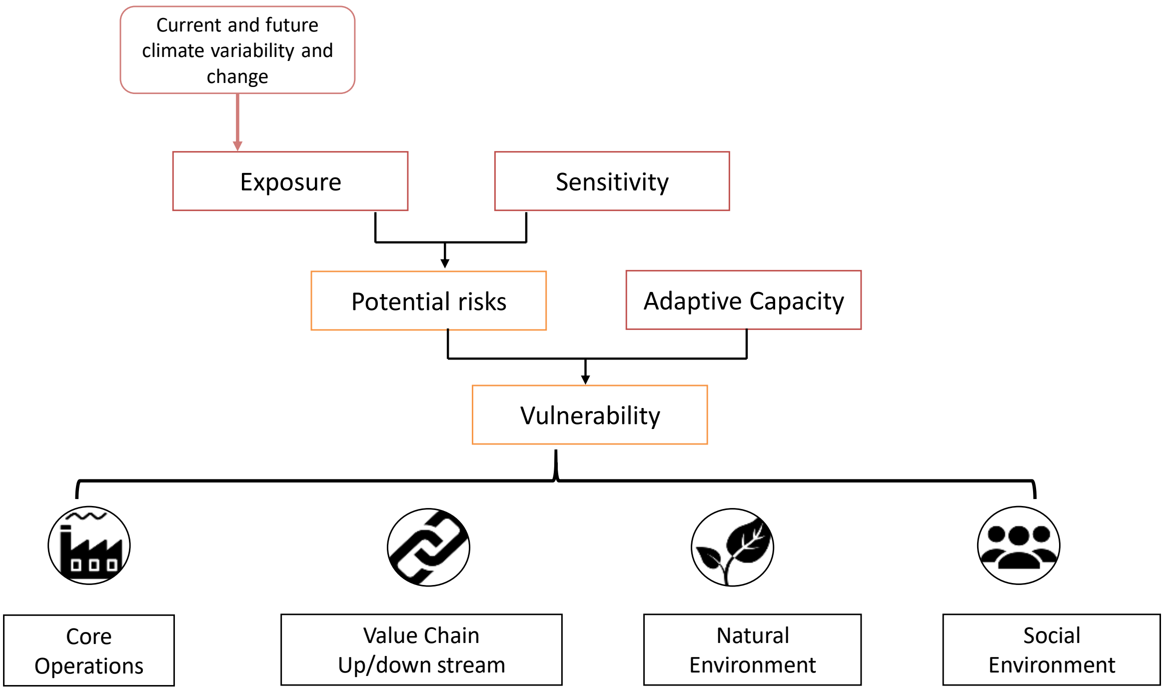

Figure 4: Vulnerability assessment process

The vulnerability assessment considers the core operations of the proposed project, the project's value chain as well as the social and natural environment which could impact the project or be impacted on by the project.

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[20] Parry, M., Canziani, O., & (eds.), et al. 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Exposure refers to what extent a system is being subjected to climate factors (e.g. temperature, precipitation). To which degree a system or group is positively or negatively affected by climate change exposure is defined by *sensitivity*. Only factors that directly impact the climate (change) are considered sensitivities. *Risks* are identified based in the climatic parameters identified in the describing the receiving environment, and how exposed and sensitive the project is in relations to these climatic changes. *Adaptive capacity* refers to "a set of factors which determine the capacity of a system to generate and implement adaptation measures"[21] which is relevant to the project's core operations.

Once all of these elements have been assessed, the vulnerability of a specific project can be defined. Vulnerability is indicated as high. Medium or low, as defined by the following table.

21 GIZ. 2014. *The Vulnerability Sourcebook Concept and guidelines for standardised vulnerability assessments*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn and Eschborn, Germany. P. 24.

Table 6: West Wits Project Climate Change Risk and Vulnerability Analysis Components

Risk analysis component	Legend and definition	
High risk	(red)	High risk implies a high likelihood of the identified West Wits Mining Project risk being worsened / exacerbated under the specified scenario. It also suggests a high impact of the risk under the specified scenario. For example a shut-down of the operations.
Medium Risk	(pink)	Medium risk implies a likelihood of the identified West Wits Mining Project risk being continued under the specified scenario, which is still material to the mine's core operations, value chain and the broader community.
Low Risk	(green)	Low risk implies a lower likelihood of the identified West Wits Mining Project risk being worsened / exacerbated under the specified scenario. It also suggests a lower impact of the risk under the specified scenario to the mine.

Climate change-related risks were divided into two major categories, namely physical risks and transitional risks. This follows the Task Force on Climate-Related Financial Disclosures' (TCFD) new, only recently published, direction around standardised assessment and reporting of climate change risks.

The TCFD defines physical and transitional risks as follows:

- **Physical risks**: Physical climate change risks can be event driven (acute) or can be longer-term shifts (chronic) in climate patterns. Physical risks may have financial implications for the proposed mine, such as interruption of operations, direct damage to assets and indirect impacts from supply chain disruption.
- **Transition risks:** Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk for the proposed mine.

The risks are classified as either low or high depending on the emissions scenario. Physical risks are higher and regulatory risks are lower under the unmitigated emissions scenario, as this scenario is expected to increase global temperatures by 6 °C which would for example increase the risk of heat stress.

Typically, physical risks are lower and regulatory risks are higher under the mitigated emissions scenario, as this scenario aims to keep temperatures at 2 °C or below. The mitigated emissions scenario is supported by the Paris Agreement and will be achieved as countries set ambitious Nationally Determined Contributions (NDCs). As country's work towards their NDCs, additional regulations may be put in place to limit emissions from fossil fuel intensive industries or encourage renewable energy development.

5 Impact of Project on Climate Change

The greenhouse gas emission impacts of the West Wits Project are analysed in terms of both South Africa's national GHG inventory and climate change, as well as the global inventory and climate change. The impact on South Africa's inventory is the departure point for this assessment because the inventory is one of the tools which government uses to determine national and sectoral GHG mitigation targets, which are set within the context of the global emissions inventory and climate change.

5.1 Quantification of the Project's GHG Emissions

The West Wits Project's construction and operational (both open cast and underground) GHG emissions are summarised in the following Table 7. The emissions are grouped into direct (scope 1), indirect (scope 2) and other indirect (scope 3) sources for all three phases of the mining project's lifetime.

Table 7: Summary of the GHG emissions calculated for the proposed West Wits Mining Project

Emission categories	Total (construction and operations)	Construction	Operations (open cast and underground)
Direct (Scope 1) Emissions	802 tCO_{2e}	619 tCO_{2e}	183 tCO_{2e}
Indirect (Scope 2) Emissions	103 271 tCO_{2e}	-	103 271 tCO_{2e}
Other Indirect (Scope 3) Emissions	130 185 tCO_{2e}	7 050 tCO_{2e}	123 135 tCO_{2e}
Total Emissions	**234 257 tCO_{2e}**	**7 669 tCO_{2e}**	**226 589 tCO_{2e}**

The proposed West Wits Project is expected to generate approximately 802 tonnes of carbon dioxide equivalent (tCO_2e) of **direct emissions** over the mine's lifetime, which is 0.3% of the total calculated emissions. The direct emissions are from the combustion of diesel and are considered to be within the direct control of the mine. The bulk (99.7%) of the mine's lifetime emissions are however categorised as indirect emissions which arise during the operations phase, highlighted in the following Figure 5.

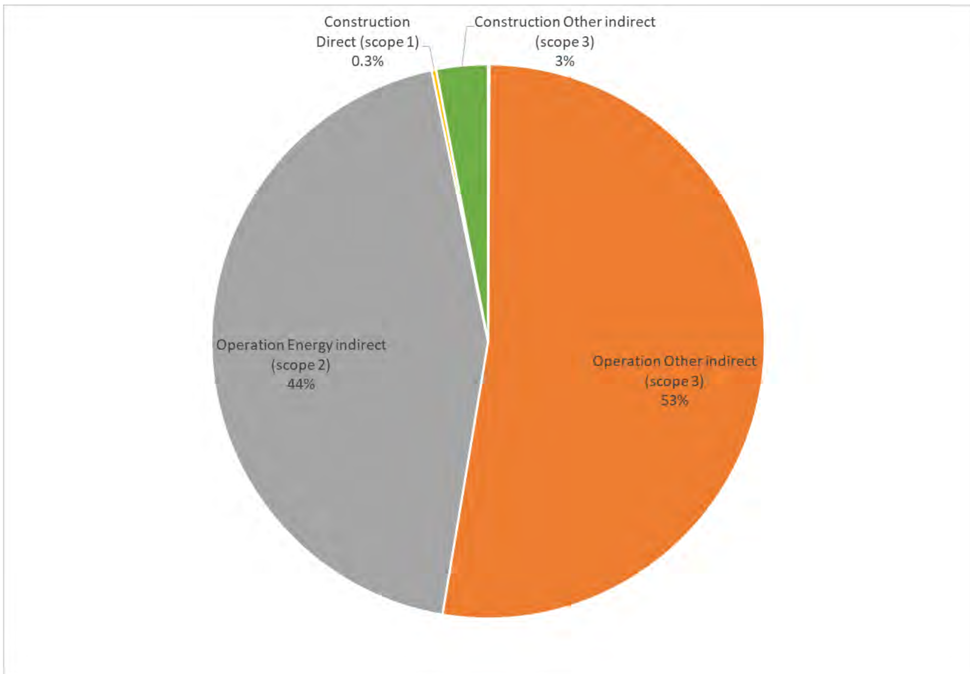

Figure 5: Distribution of lifetime GHG emissions generated by the proposed West Wits Mining Project

Emissions from the consumption of grid-based electricity (energy indirect emissions) during operations accounts for a material portion (44%) of the project's lifetime emissions. The bulk (82%) of the other indirect emissions arise from the processed sold goods category. This category refers to the emissions that arise during the downstream processing of the West Wits mining material in a toll treatment plant. The main source of emissions in the toll treatment plant process is assumed to also arise from the consumption of grid-based electricity.

No alternative technology or process scenarios have been considered in the West Wits environmental authorisation application to the Department of Mineral Resources. Therefore, no alternative GHG inventory scenarios were calculated for the project. The West Wits mine facilities will require new facilities and infrastructure, which will be built using the best available and economically feasible technologies and inputs. Therefore, the only GHG mitigation options currently available are increases in efficiencies during the operational phase. These may include fossil fuel resource efficiencies or the replacement of equipment with more efficient technologies, as these are needed or become available.

5.2 Impact of project on both South African and Global Inventories

To gain a comprehensive understanding of the impacts of the West Wits Projects emissions one must consider the emissions within the context of the national and international GHG reduction plans.

5.2.1 South African context

The IPCC's Fifth Assessment Report (IPCC, 2014) indicates that the world can emit 1,010 gigatons of CO_2e if the effect of climate change is to be limited to a 2 °C temperature increase. This figure is the global carbon budget. South Africa's share of this global budget is calculated based on the national population figure of 58 million people (Stats SA, 2018) as a percentage of the global population of 7.7 billion people (Worldometers, 2019). South Africa's carbon budget in this respect is therefore approximately 7,572 Mt CO_2e.

The following impact ratings have been identified as a means of benchmarking GHG inventories, over the lifetime of the specific activity, related to emissions that occur within the boundaries of South Africa:

- **Low (inventory of 10 thousand tCO_2e):** 0.00013% of South Africa's carbon budget
- **Medium (inventory of 1 million tCO_2e):** 0.013% of South Africa's carbon budget
- **High (inventory of 10 million tCO_2e):** 0.13% of South Africa's carbon budget

The West Wits Project's calculated emissions inventory, in terms of South Africa's remaining portion of the global carbon budget, is presented in the following Table 8

Table 8: West Wits Mining Project's emissions relative to South Africa's carbon budget

South Africa's carbon budget based on proportion of local population	7,572 Mt CO_2e	
West Wits Project's Total Scope 1 (lifetime)	0.00001%	**of South Africa's carbon budget**
West Wits Project's Total Scope 1 & Scope 2 (lifetime)	0.001%	
West Wits Project's Total Scope 1, Scope 2 & Scope 3 (lifetime)	0.0031%	

The **impact of the total West Wits Project's greenhouse gas inventory within a domestic context** is therefore considered to be **low-medium** because the total lifetime inventory is expected to consume approximately 0.0031% of South Africa's carbon budget. The value of 0.0031% is above the low-materiality threshold (0.00013%) but below the medium-materiality threshold (0.013%) of South Africa's carbon budget.

5.2.1 Global context

The global nature of climate change makes it difficult to distinguish between local and international climate change drivers. Global anthropogenic climate change is caused by the accumulated GHG emissions from global emitting sources. The GHG emissions from the proposed West Wits Project, when considered in isolation, are unlikely to have any specific significant impact on the global GHG inventory which is currently estimated at 37.1 billion tCO_2e (Harvey, 2018).

The cumulative impacts of the GHG emissions from the proposed West Wits Project must also be considered. The global inventory will undoubtedly increase, particularly when the mine's emissions are quantified in conjunction with the other emission-intensive activities scheduled for implementation around the world.

5.3 Impacts on both South African and Global Climate Change

The high-level impacts (considered to be 'minor in magnitude') from the domestic and global greenhouse gas inventories perspectives do not however reflect the impacts of the West Wits Project from a domestic or global environmental perspective.

Each participant in the global economy has an individual responsibility to minimise their negative contributions to climate change. There is therefore a collective responsibility to address the global challenge of climate change despite the inability of attributing specific GHG emissions from the mine to specific climate change effects.

The impacts of the West Wits Project's GHG emissions have therefore been assessed in the following tables, as per the Environmental Impact Criteria detailed in Section 4.1.2 of this report.

The West Wits Project impacts from both a construction and an operational perspective are presented in the following

Table 9 (construction phase) and

Table 10 (operations phase) respectively.

Table 9: Climate change impacts of the West Wits Mining Project emissions during construction

<table>
<tr><td colspan="3">Nature: The GHG emissions produced as a result of constructing the proposed West Wits Project will contribute to the global phenomenon of anthropogenic climate change. Numerous global changes are likely to manifest due to climate change, although none that can be attributed directly or indirectly to the specific GHG emissions of any individual source, such as the proposed mining project.
The total emissions (Scope 1, 2 and 3) from the construction of the mine (estimated to be developed within three years) are calculated to be 7.7 thousand tCO_2e, which is 0.00010% of the South African carbon budget of 7,572 $MtCO_2e$. The value of 0.00010% is below the 0.00013% ‘low’ material threshold in relation to the national carbon budget.</td></tr>
<tr><td></td><td>Without Mitigation</td><td>With Mitigation</td></tr>
<tr><td>Spatial Scale</td><td>National/International</td><td>National/International</td></tr>
<tr><td>Duration</td><td>Permanent</td><td>Permanent</td></tr>
<tr><td>Magnitude</td><td>Low impact</td><td>Low impact</td></tr>
<tr><td>Probability</td><td>Definite</td><td>Definite</td></tr>
<tr><td>Significance</td><td>Medium</td><td>Medium</td></tr>
<tr><td>Status of impact</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Reversibility</td><td>None</td><td>None</td></tr>
<tr><td>Irreplaceable loss of resources?</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Can impacts be mitigated?</td><td>No</td><td>No</td></tr>
<tr><td colspan="3">Mitigation: No specific mitigation measures, in terms of technology alternatives, have been identified for the GHG emissions related to the project as no additional sites or technologies have been identified. The mining operations will be constructed using the latest available and economically feasible technologies. GHG mitigation options are therefore not currently available. In addition, open cast and underground mining have been considered for various shafts, and selected by the Applicant.</td></tr>
<tr><td colspan="3">Cumulative impacts: The emissions from the construction phase of the mine are globally cumulative in their impact due to the global scope of climate change and the long timeframes that GHG emissions are expected to remain in the atmosphere.</td></tr>
<tr><td colspan="3">Residual risks: The residual risk is the same as the risk without mitigation because no mitigation measures have been identified.</td></tr>
</table>

Table 10: Climate change impacts of the West Wits Mining Project emissions during operations

Nature: The GHG emissions produced as a result of both the mine operations will contribute to the global phenomenon of anthropogenic climate change. Numerous global changes are likely to manifest due to climate change, although none that can be attributed directly or indirectly to the specific GHG emissions of any individual source, such as the proposed West Wits Project. The total Scope 1, 2 and 3 emissions from the operational phase of the mine are calculated to be 227 thousand tCO_2e, which is 0.0030% of the South African carbon budget of 7,572 $MtCO_2e$. The major sources of emissions are related to the consumption of grid-based electricity directly in the operations as well as in the downstream processing of the sold material in a toll treatment plant. These combined emissions relating to the consumption of electricity contribute 92% of the total emissions during operations. The total emissions from the mining project's operations (0.0030%) as a percentage of the South African carbon budget are therefore above the 'low'-materiality threshold (0.00013%) but below the 'medium'-materiality threshold (0.013%).		
	Without Mitigation	**With Mitigation**
Spatial Scale	National/International	National/International
Duration	Permanent	Permanent
Magnitude	Low-Medium	Low-Medium
Probability	Definite	Definite
Significance	High	High
Status of impact	Negative	Negative
Reversibility	None	None
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	No	No
Mitigation: No mitigation measures have been identified for the GHG emissions related to the project as no additional sites or technologies have been identified. The mining operations will be constructed using the latest available and economically feasible technologies. GHG mitigation options are therefore not currently available. In addition, open cast and underground mining have been considered for various shafts, and selected by the Applicant. The biggest impact of the project lies in the direct and indirect consumption of coal-based electricity.		
Cumulative impacts: The emissions from the operations phase of the mine are globally cumulative in their impact due to the global scope of climate change and the long timeframes that GHG emissions are expected to remain in the atmosphere.		

Residual risks: The residual risk is the same as the risk without mitigation because no mitigation measures have been identified.

The assessment results indicate that the emissions from both the construction and operations of the mining project will have a low-medium impact significance rating.

It must be noted however that the duration that the project-related GHG are assumed to remain in the atmosphere renders the impacts (limited as they may be) effectively irreversible with the impacts of anthropogenic climate change, in many cases resulting in the irreversible loss of resources.There are options to mitigate the GHG emissions from the operation phases of the mining project. However, these options are not able to alter the impact that the GHG emissions will have on climate change in terms of their extent, duration or probability. It is only the magnitude of the GHG emissions impact that can be reduced by reducing the quantity of emissions.

6 Impacts of Climate Change on the Project

Companies in many industry sectors in South Africa are already experiencing detrimental climate change impacts. These include, for example, prolonged regional droughts which result in water constraints and operational stoppages as well as flash floods impacting infrastructure, water storing facilities and water discharge quality. However, the most significant effects of climate change are likely to emerge over the medium- to long-term. The timing and magnitude of these effects are uncertain. To account adequately for the potential climate change effects in planning processes, companies need to consider how climate related risks and opportunities, as well as the associated impacts, may evolve under different conditions.

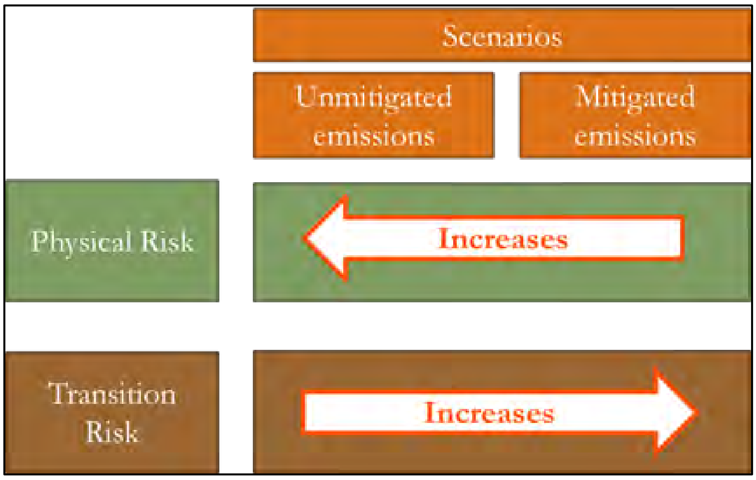

Figure 6: Forward Looking Scenario Analysis[22]

The proposed West Wits Project could face a number of climate change related risks across its core operations, its value chain, as well as risks related to the social and natural environment within which the mining project will operate, under both a globally mitigated emissions scenario and a globally unmitigated emissions scenario. Under an unmitigated emissions scenario the physical risks of climate change are high, as policies and measures have not been put in place to reduce emissions (Figure 6). This would mean that the transitional risks would be low under an unmitigated emissions scenario. Physical risks are higher as the global temperatures are expected to increase by 6°C, which could for example increase the risk of heat stress.

However, under a mitigated emissions scenario, transitional risks are high as the world's economy moves towards a low carbon economy by implementing nationally determined contributions. The mitigated emissions scenario is supported by the Paris Agreement and will be achieved as countries set ambitious Nationally Determined Contributions (NDC). The 24th Conference of the Parties (COP 24) was held in Katowice, Poland December 2018. The main issue under consideration at this event was that the world is not on track for a 2°C target. In this regard countries must negotiate and determine how to achieve such a target, and how to possibly accelerate efforts to achieve a 1.5°C target.

The following section will provide an assessment of the climate change risk and vulnerabilities related to the mining project's core operations and the value chain. Following these section is the assessment of the key issues related to the social and natural environment.

[22] Promethium Carbon

6.1 Core operations

Core operations for this assessment include everything within the fence of the proposed West Wits Project. The core operations are expected to be exposed to both physical and transitional risks as a consequence of climate change.

6.1.1 Exposure

The West Wits Project's core operations are exposed to the following changing climatic parameters:

	Land-surface temperatures	Rainfall	Extreme events
Current observations	Overall land-surface temperatures increased	Increased variability, overall decrease in number of rainfall days	The number of hot extremes have increased
Future trends in climate change	Increased hotter and drier conditions	Increased variability to continue, increase in the frequency of extreme rainfall events	Annual frequency of very hot days projected to increase Increase in heavy precipitation Increased frequency, intensity and severity of thunderstorms

6.1.2 Sensitivity

Due to increased temperatures, prolonged periods of drought and severe weather events could all negatively influence the core operations of the mine. The mine is dependent on water and energy for continued functionality. However, water provision is highly sensitive to increased temperatures and prolonged periods of drought. In addition, the continuation of electricity supply would be sensitive to increased regulatory requirements in the form of the proposed carbon tax. Finally, from an infrastructure perspective, the mine is sensitive to extreme weather events such as increased hail storms, flash flooding and increased temperatures.

6.1.3 West Wits Project's core operations risks

6.1.3.1 Physical risks: Increased temperatures

The West Wits Project is faced with the physical risks of increased temperatures and increased intensity and variability of rainfall due to climate change.

Higher temperatures have the potential to increase electricity costs, as more cooling will be required to maintain temperatures at the legal operating limit underground. In order to mitigate this risk, it is suggested that the West Wits Project further explores the potential for off-grid renewable energy, so as to reduce exposure to the potential electricity price increases. The project could also consider technological developments in ventilation and cooling design, so as to effectively reduce their electricity consumption and the associated costs.

Heatwaves, due to higher temperatures, may have little impact on employee health and safety underground due to the fact that underground temperatures are so strictly regulated and actively managed. The proposed mine's surface operations however may be more susceptible to heatwaves and resultant heat exhaustion. Developing heat stress and dehydration strategies are important to ensure the health and safety of employees. Training employees on the health risks of dehydration may also prove effective in mitigating this risk.

From an operational perspective, heat stress directly impacts on labour productivity. Labour productivity is projected to decline significantly under a high emissions scenario. Prolonged hot periods and increased temperatures may also reduce the operating efficiency of machinery or heavy goods vehicles. Equipment operating thresholds may be exceeded during episodes of extremely high temperatures. High temperatures could lead to extended use of air conditioners within trucks, which would increase diesel consumption as the truck would need to be kept running to operate the air conditioner.

> *Higher temperatures pose profound threats to occupational health and labour productivity, particularly for people undertaking manual, outdoor labour in hot areas. This indicator [higher temperature]shows the change in labour capacity (and thus productivity) worldwide and for rural regions specifically, weighted by population. Loss of labour capacity has important implications for the livelihoods of individuals, families, and communities, especially those relying on subsistence farming.* (Watts, et al., 2018)

In addition to the above, increasing drier and hotter climatic conditions contribute to the prevalence of dust. From an operational perspective, an increase in dusty conditions can also increase the cost of maintenance on diesel trucks, as the air filters will need to be replaced more frequently.

6.1.3.2 Physical risks: Flash flooding and long term water stress

Water security and groundwater are considered as part of this specialist climate change impact assessment. This is due to the fact that water is a key resource that will be affected as a result of climate change. In the case of the proposed West Wits Project, water is considered from a regional perspective. Climate change impacts related to water do not only affect the source of water directly related to the mine or the zone of influence, as delineated in the Groundwater study submitted with the Environmental Impact Assessment.

Climate change is expected to increase rainfall intensity and variability. Climate change impacts in the Gauteng Province include an increase in the number of extreme rainfall events- hailstorms, damaging winds, thunderstorms and flooding. This is due to the fact that even though the region is becoming dryer, the intensity of rainfall on wet days increases.

Such intense rainfall events could result in localised flash floods. Flash flooding could necessitate the unauthorised discharge of water at the mine. Although a number of protocols are in place in terms of legislation to manage these situations, the frequency of intense rainfall events could increase and is highlighted in this report as a risk which will need to be managed by the mine.

Appropriate mitigation measures would need to be investigated in conjunction with storm water management experts to mitigate the risks associated with increased intense rainfall events.

One of the key challenges in planning for climate change relate to the increased variability related to changing climatic parameters. In this regard the long-term scenarios for the study area include not only increased rainfall intensity but also reduced rainfall. Reduced rainfall could lead to extended drought periods. Theincreased intensity and variability of rainfall coupled with higher temperatures can contribute to drought conditions.

6.1.3.3 ***The impacts of drought periods on the proposed West Wits projec are twofold. During drought periods, the West Wits Project onsite water flows will be reduced, which will result in an increased demand for water from Rand Water. This would ultimately put the West Wits Project at risk of increased operational costs. In addition, drought periods may affect Rand Water's ability to supply required volumes of water to the West Wits Project, due to water restrictions. In periods of drought, it would be expected that water supply for human consumption would be prioritized over water supply for industry.*** Physical risks: Land rehabilitation

Mine closure plans and the development of sustainable post-mine life scenarios may also be impacted by climate change.

In terms of land rehabilitation it is critical to consider the impact of the changing climate on the local vegetation and vegetation establishment patterns. The increasing drier conditions and water scarcity should be considered in terms of post-mine life re-vegetation and rehabilitation alternatives.

It is imperative that the mine closure plan considers climate change and the potential impacts thereof to inform closure planning for a sustainable post-mine life land use.

The majority of the physical risks mentioned in sections 6.1.3.1-6.1.3.3 above, are specific to the operational phase of the mine. Dust pollution would be of concern in both the construction and operational phase of the proposed West Wits Project. However it should be noted that although the construction of the mine will occur within an immediate timeframe, this phase may still experience higher temperatures and drought conditions caused by climate change.

6.1.3.4 Transitional risks

A key transitional risk to consider for the West Wits Project is the second phase of the South African Carbon Tax. The Carbon Tax will come into effect, at current estimations, in June 2019. The second phase of the tax is expected to commence from 2023 and this will include a linkage to the national sectoral emission targets being developed by government. Once finalised, the sectoral emission targets may mandate eligible entities, potentially the West Wits mine, to develop carbon budgets within which they must operate or face penalties.

The announced carbon tax could potentially have an impact on the price of electricity. National Treasury has however given a commitment that there will be no impact of carbon tax on the electricity tariff up to 2020. After 2020 the carbon tax impact could be in the order of 5 cents per kWh, increasing to a potential level of 8 cents per kWh by 2030.

This will further increase the mine's operational costs in the order of 5 cents per kWh, increasing to a potential level of 12 cents per kWh by 2030. Costs of electricity could therefore increase by just under ZAR 1 million per year between 2022-2030 and by ZAR 2.3 million per year from 2030.

There are current costs related to the carbon tax that need to be considered for the West Wits project. The West Wits Project's indirect carbon tax liability with regards to the tax on diesel purchases will be in the region of an additional ZAR 8c/litre. It is estimated that the West Wits Project could consume approximately 390 000 litres of diesel per year of operation. An increase of ZAR 8c could mean an additional R310 000 spend on diesel per year.

6.1.4 Vulnerability – core operations

Increasing temperatures, the risk of flash flooding, increased water pressure and the uncertainty related to the impacts of the second phase of the South African carbon tax, contribute to the climate change related risks faced by the project's core operations. This is further summarised in the table below.

Table 11: Core operations vulnerability to climate change

Risks	Baseline scenario with no greenhouse gas mitigation by global community	Scenario with mitigation to limit temperatures below 2°C
Core Operations – West Wits Project		
Heat stress	High Risk	High Risk
Drought	Medium Risk	Medium Risk
Severe weather events (e.g. storms, flash-flooding)	High Risk	Medium Risk
Regulatory obligations	Low Risk	High Risk

The key risks associated with the core operations relate to increased temperatures which could result in health risks for the mine's labour force as well as severe weather events such as flash floods.

6.2 Upstream value chain

Electricity supply and water availability are key components of the proposed West Wits mine's upstream value chain. The upstream value chain could be exposed to both physical and transitional risks, as a consequence of climate change. The exposure of the value chain, although similar to the core operations, relate to a much broader perspective in terms of key upstream elements.

6.2.1 Exposure

The West Wits Project's value chain is exposed to the following changing climatic parameters.

	Land-surface temperatures	Rainfall	Extreme events	Prolonged periods of drought
Current observations	Overall land-surface temperatures increased	Increased variability, overall decrease in number of rainfall days	The number of hot extremes have increased	Drier periods are more frequent
Future trends in climate change	Increased hotter and drier conditions	Increased variability to continue, increase in the frequency of extreme rainfall events	Annual frequency of very hot days projected to increase Increase in heavy precipitation Increased frequency, intensity and severity of thunderstorms	Increased temperatures and rainfall variability will result in prolonged periods of drought

6.2.2 Sensitivity

The West Wits Project's value chain is highly sensitive to climate change. For the purposes of this report the following key value chain elements have been assessed in terms of climate change:

- Logistical considerations;
- Water accessibility; and
- Energy provision.

Water and energy provision are sensitive to climate change from an availability, capital and a regulatory perspective.

6.2.3 West Wits Project's value chain risks

6.2.3.1 Physical risks: Electricity

Key to the West Wits Project's chain is electricity. The mine will use in the order of 7.1MW of electricity. Electricity will be supplied by Eskom. In terms of climate change impacts there are two key considerations with regards to Eskom: the first being water and the second being the regulatory implications of the proposed carbon tax on the power utility.

Water is a key input in electricity generation. During 2017 Eskom consumed 1.43 litres of water for every kWh of electricity produced[23]. In this regard water scarcity or water stress pose a threat to continued electricity provision. Considering South Africa's increasing drier climate, water related risks to energy provision must be considered.

The bulk of the Eskom power stations are situated in the Mpumalanga region which, is a water stressed Province. The overall water stress, as determined by the World Resources Institute Aqueduct, of the Mpumalanga region is "*Medium to High*" and is shown in Figure 7 below. In addition climatic models predict that the Mpumalanga Province is going to become increasingly drier and hotter.

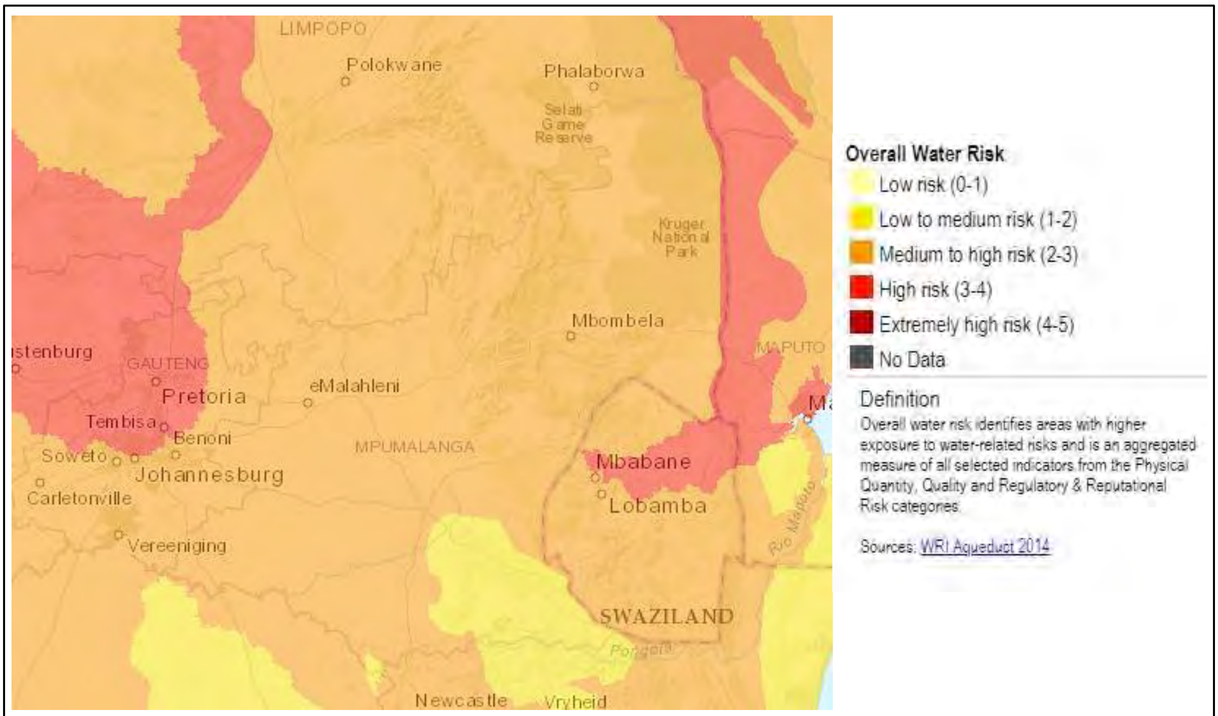

Figure 7: Water stress in Mpumalanga region[24]

Water scarcity and increasing constraints in terms of access to water could negatively impact Eskom's functionality, resulting in strain on energy users. In addition, disruptions in Eskom's ability to generate power could negatively impact on the mine's ability to run its operations sustainably.

In addition, Eskom emits in the order of 200,000 tonnes of CO_2e per year. Eskom's emissions are governed by the Integrated Resource Plan (IRP) that is published by the Department of

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[23] ESKOM. 2018. *Eskom Integrated Annual Report*. Eskom, Johannesburg, South Africa.
[24] WRI. 2019. – Measuring, mapping and understanding water risks around the globe (https://www.wri.org/our-work/project/aqueduct). Accessed 25 February 2019.

Energy. The reduction in emissions from the South African grid as per the updated version of the 2010 Integrated Resource Plan is shown in Figure 8 below. The decarbonisation of Eskom's operations could potentially carry a pricing risk for electricity.

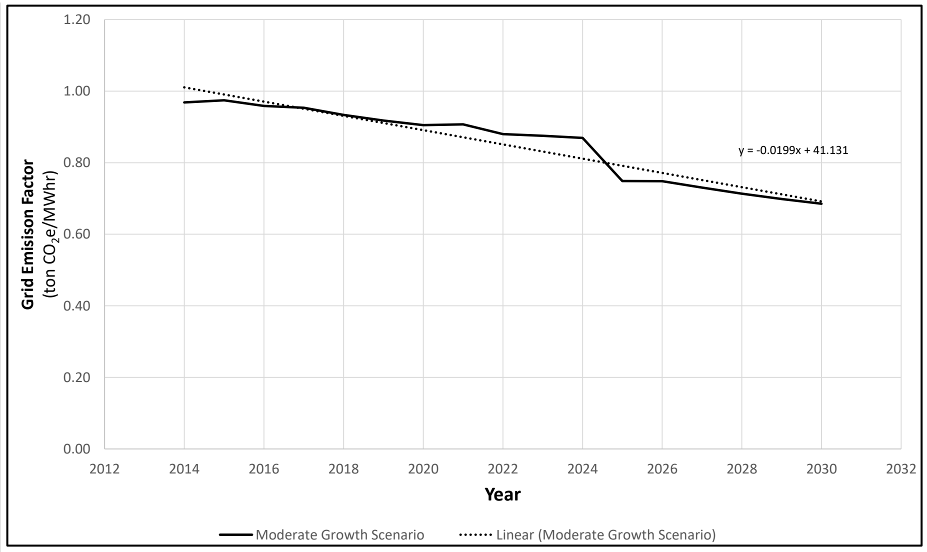

Figure 8: Grid emission factor projection (Department of Energy, 2016)

There is a price risk in the Eskom tariff in that many of Eskom's clients are installing their own renewable energy (mostly solar PV). The impact of this is that the sale of electricity by Eskom will reduce. Reduced sales will reduce Eskom's revenue and may lead to increased electricity prices as Eskom still needs to cover its costs.

6.2.3.2 Physical risks: Water stress

Climate projections for the Gauteng Province indicate drier temperatures and prolonger dry periods. The impacts of drought on the proposed West Wits project are twofold. During drought periods, the mine's onsite water flows will be reduced, which will result in an increased demand for water from Rand Water. This would ultimately put the West Wits Project at risk of increased operational costs. In addition, drought periods may affect Rand Water's ability to supply required volumes of water to the mine, due to water restrictions. In periods of drought, it would be expected that water supply for human consumption would outstrip water supply for industry. This is especially relevant given the urban context of the proposed project and existing social dependencies in the surrounding community.

The long-term scenarios for the area include both reduced or increased rainfall, yet both scenarios, coupled with higher temperatures, could lead to extended drought periods and increased intensity and variability of rainfall.

Surrounding water threats could also lead to social and environmental pressures on the proposed West Wits Project. Increased competition for water, within the metropolitan areas, could increase pressures on the proposed mine for water use as well as impact the availability of water for use due to seasonal or annual rainfall variability.

Extreme weather events such as storms or droughts, due to changes in rainfall variability and intensity, may put the labour supply for the proposed West Wits Project's value chain at risk. If labour within the value chain is negatively impacted, then there is a risk that the mine's suppliers may be unable to operate or supply the mine with critical products. This risk could be mitigated by diversifying the West Wits Project suppliers, so as to minimise reliance on one main supplier.

6.2.3.3 Transitional risks

The proposedcarbon tax is also expected to impact industries such as the cement industry. Mitigating these value chain risks could include budgeting for increased costs on upstream product purchases as well as engaging with suppliers on the price impacts of the proposed carbon tax. National Treasury has indicated that carbon tax will not impact on the price of electricity up to 2020.

6.2.4 Vulnerability – value chain

Key vulnerability aspects with regards to the West Wits Project's value chain relate to energy and water availability and costs of these resources.

Risks	Baseline scenario with no greenhouse gas mitigation by global community	Scenario with mitigation to limit temperatures below 2°C
Value Chain – West Wits Project		
Disrupted upstream supply chain - Electricity	High Risk	Medium Risk
Water supply	Medium Risk	Medium Risk
Regulatory obligations	Low Risk	Medium Risk

6.3 Social environment

In terms of climate change, a warmer future with an increase in extreme weather events is predicted for Gauteng province.[25] The West Wits Project is located immediately south of Roodepoort and north of Soweto in the Gauteng province. The project furthermore falls within

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25 City of Johannesburg Air Quality Management Plan (February 2017) available at https://www.joburg.org.za/documents_/Documents/By-Laws/Draft%20CoJ%20AQMP.pdf

the City of Johannesburg Metropolitan Municipality and its operations will take place within both the Roodepoort Magisterial District as well as the Krugersdorp Magisterial District. Johannesburg, like all Southern African cities is extremely vulnerable to climate change impacts. Temperature increases and weather variability threaten to directly or indirectly disrupt systems critical to the survival of cities in the region. The challenge for cities such as Johannesburg to respond to the impacts of climate change is particularly serious, due to the often precarious nature of living conditions and livelihoods that many face. For those living just outside of poverty, but still with very low incomes very slight external changes can prompt a shift to poverty. These may include social, economic, political or environmental changes such as droughts, increasing food or damage to property due to unexpected events.

Communities surrounding the West Wits Project often live in informal settlements, informal backyard dwellings or informally occupied buildings. This is especially so for Region D of the project which encompasses the whole of Soweto. Informal living environments are at times located in high-risk locations (such as flood plains) and often with minimal bulk and public services, such as waste collection and management, public transport, access to potable water, sanitation, and health facilities. As such, it is clear that certain portions of the population are more at risk to the seemingly slight and gradual changes that climate change poses.

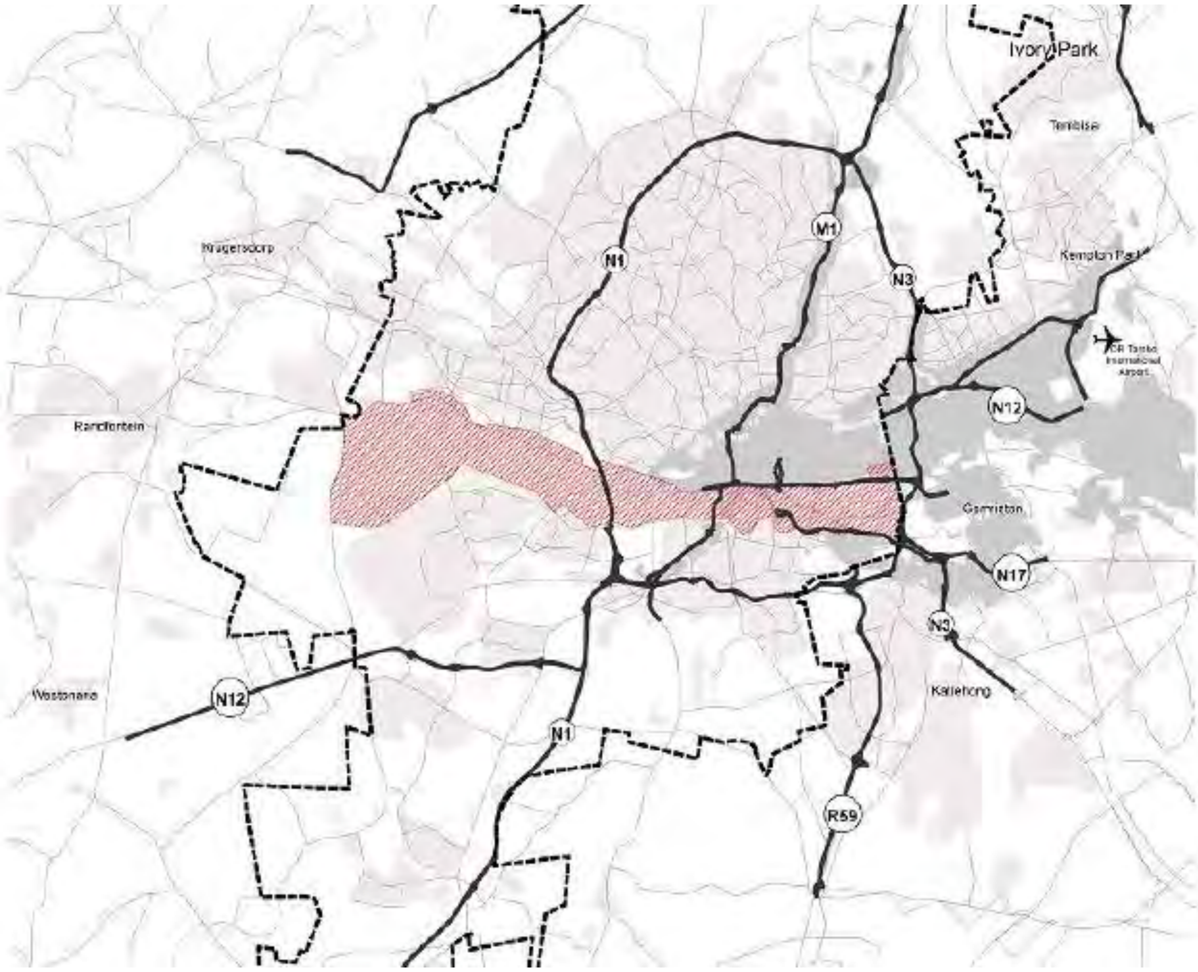

Figure 9: Johannesburg Mining Belt[26]

There are a number of key opportunity areas along the mining belt, including its potential to integrate the areas of Soweto with the broader urban and economic opportunities around Roodepoort towards Mogale City, and its role in facilitating the southern expansion of the existing Johannesburg Inner City area. The proposed West Wits project could form a key component of integrating historic mine areas into surrounding urban patterns. In this regard opportunities include improving basic infrastructure in the areas surrounding the mine, which will enable communities to be more climate resilient to climatic threats such as water scarcity, drought and flood risks.

This must however be considered in the context of some of the environmental and pollution linked realities associated with historical as well as future mining in the area. It cannot be ignored that large parts of the mining belt are polluted. Such pollution poses health threats to the

[26] Source: City of Johannesburg Metropolitan Municipality *Spatial Development Framework 2040.*

residents surrounding the project area and threatens water resources especially through acid mine drainage.

However, adhering to spatial planning principles, accommodating industrial uses within specific areas and managing urban sprawl all contribute to effective climate change adaptation. In this regard, the City of Johannesburg Metropolitan Municipality has drafted a development strategy for the City of Johannesburg Mining Belt.[27] The strategy aims to:

- Rehabilitate degraded and polluted land and mitigate the effects of acid mine drainage as a key intervention, which will have to be phased over a long period of time. This includes exploring the ecological structure of the areas as a key determinant to a future settlement pattern: Geotechnical and undermining constraints will inform land use and building typologies. This process is required to reclaim land for development.
- Develop partnerships which will aid in the task of rehabilitating and developing the mining belt is vast. This will include partnerships with many stakeholders such as mining companies, land owners, various government departments across spheres, and the communities affected (including informal dwellers). It must however be noted that the project of rehabilitation is a multi-decade one. As such partnerships should be continued where they exist, or entered into where they do not.
- Invest in major bulk infrastructure. This will be linked to reclamation of degraded land and connectivity interventions to ensure that communities are able to access basic infrastructure to facilitate economic development.
- Connect the mining belt by creating a direct road between Soweto and Roodepoort.
- Create Jobs which and increase economic activity within the mining belt.
- Provide a significant amount of low income housing solutions for the area. The residential infill strategy will support the intensification of new economic development. The planning of the residential area will also consider the needs of the community to be able to access economic activities, such as the West Wits Project, for that reason, the government will aim to provide public transport mechanisms which enables the mining belt's workforce to commute more easily.

Considering the above role of mining projects within the Johannesburg mining belt, the proposed West Wits mining project could contribute a number of positive aspects to the study area. The project could assist in addressing localised historic mining related challenges through improved tailings facility management, dust control and water management. The introduction of measures to rehabilitate existing mining land provides an opportunity to reduce risks such as

[27] Mining Land (West) Strategic Area Framework.

water contamination, which are generally aspects which are exacerbated by climate change factors such as increased temperatures.

There are also other key issues to consider in terms of climate change impacts on the social environment which is discussed below:

6.3.1 Air Quality

Ambient air quality in the project area is likely to be influenced by local sources as well as emissions from various remote sources. The most significant of these sources within the Soweto and Roodepoort region include:

- fugitive dust emissions from current mining operations and historical dumps;
- vehicle tailpipe emissions;
- vehicle entrained dust from paved and unpaved roads;
- household fuel combustion by means of coal, wood and paraffin;
- biomass and veld burning; and
- various miscellaneous fugitive dust sources, including: agricultural activities, and wind erosion of open areas.

Potential receptors in the area comprise residential areas, institutional areas, educational areas, rural type areas, industrial and the natural environment.

Air Quality remains a key social concern in the area surrounding the project area of the West Wits Project. Although climate change and air pollution are different in nature, there is a close correlation between these aspects. Climate change does have the potential to impact air quality. For example, it is projected that there will be intensification of the subtropical high pressure belt, particularly during winter months, which is characterised by temperature inversions. This impact on inversions will result in the increased potential for pollutants to become trapped under the temperature inversion, which will reduce the dispersion capacity of pollutants within the City of Johannesburg Metropolitan Municipality.

Considering this the residence time of air pollutants in the atmosphere may change as climatic conditions change. In this respect changes in amount and patterns of precipitation are very relevant to the distribution of air pollutants[28]. Under hotter and drier conditions, as a result of climate change, air pollution could worsen. This is a key aspect to be considered in the monitoring of air quality thresholds and standards at the West Wits Project once operational.

6.3.2 Human health

Air-quality also plays a vital role in human health. Poor levels of air quality are an ongoing issue within the City of Johannesburg. From a health-related perspective, those most at risk from air pollution include the elderly, individuals with pre-existing heart or lung disease, asthmatics and children. Notwithstanding these direct health impacts, there are numerous secondary economic impacts arising from, among other issues: increased health costs, lost productivity, reduced tourism and lowering of property values. Loss of productivity due to pollution-related illnesses is also a direct economic cost.

In addition to the above, there are numerous health risks related to climate change which may have an impact on the project area's social environment if appropriate measures are not put in place to mitigate and adapt to the effects of climate change. These health risks are discussed below.

- **Vector-borne diseases include Schistosomiasis (Bilharzia)**: The spread of Schistosomiasis is related to high rainfall and can be expected to spread when floods are followed by high temperature allowing the water snail to increase its range. Although cold temperatures will break the life-cycle of the host, it is considered that the northern parts of Gauteng may see an increase in Schistosomiasis cases. The City of Johannesburg may also see an increase in the amount of infected individuals, due to migration of the disease.

  Cholera: While, strictly speaking, the risk of cholera is related more to flooding than to direct climate change-driven biodiversity and habitat impacts within the CoJ, it is considered more appropriate to discuss this risk in the context of the diseases mentioned above. 33% of the population at present living in less than adequate housing with poor sanitation is a key factor in the spread of infectious diseases. Risk of flooding and the consequent disruption of the water and wastewater systems bring with it the threat of Cholera. Cholera is associated with poor hygiene and has a complex mode of transmission as a water and food-borne disease. Rising temperature and increased rainfall will tend to favour the spread of the disease and the reservoir of cholera in the zooplankton of water bodies. Cholera outbreaks have the potential to occur wherever clean water supplies are disrupted (which leads to unhygienic practices). There is a possibility that climate change may increase cholera outbreaks and that the bacteria may become increasingly resistant to antibiotics over time, or new strains of the bacteria may emerge.

6.4 Natural environment

Climatic changes, whether through natural or anthropogenic influences, impact directly on the natural environment. Ecosystems such as soil, biodiversity and groundwater recharge are impacted first and in turn, ecosystem services. Consequently, natural resource extraction, resource processing and eventually the social sphere will be affected[29]. This demonstrates how dependent the socio-economic system, which incorporates all social and economic aspects of a locality or region, is on the natural environment and the provision of its ecosystem services. For the purpose of this study, ecosystem services represent the natural environment. In this context, the impacts of anthropogenic climate change and the level of resilience are discussed.

6.4.1 The importance of ecosystem services and their current state

"Ecosystem services are the benefits people obtain from ecosystems." (Millennium Ecosystem Assessment, 2005, p. 5). They are regarded as "structural building blocks of global ecosystems" (Farley and Voinov 2016, p. 389).Ecosystem services, or *Nature's contribution to people* (Pascual, 2017) can include:

- **Provisioning services**, such as raw materials, food, fresh water, medicinal resources, energy, habitat creation and maintenance of genetic diversity;
- **Regulating services**, such as water purification, regulation of local climate and air quality, trees provide shade and regulate air quality by removing pollutants from the atmosphere,, carbon sequestration and storage, moderation of extreme events: wetlands regulate floods, storms avalanches and desertification, erosion prevention and maintenance of soil fertility, pollination, propagule dispersal and biological control of pests and vector borne diseases, biological control, pest and disease control, disease regulation;
- **Supporting services**, such as soil formation, nutrient and water cycling;
- **Cultural services**, such as physical and experimental interactions with nature, symbolic meaning and inspiration.

The impacts of climate change, i.e. rising temperatures, frequency and intensity of extreme weather events and changes in rainfall, will impact on ecosystem composition, processes and dynamics on a local scale.[30,31] Yet the responses to such climatic changes are difficult to predict because the interactions over different time (short- and long-term) and spatial scales (e.g. at the individual, population, community, and ecosystem level)are very complex and are also influenced by other environmental factors and drivers other than climate change. These could include, for example, varying levels of existing environmental degradation.

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29 GIZ. 2014. The Vulnerability Sourcebook Concept and guidelines for standardised vulnerability assessments. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn and Eschborn, Germany.

30 Montoya, JM, and Raffaelli, D. 2013. Climate change, biotic interactions and ecosystem services. Philosophical Transactions of the Royal Society B, 365, 2013–2018.

31 Jentsch A, Beierkuhnlein, C. 2008. Research frontiers in climate ecosystems. *Comptes Rendus Geoscience*, 340, 621-628.

6.4.2 Ecosystem services in urban areas

Urban and built up areas, which the proposed West Wits Project will be situated in, are highly dependent on the provisioning as well as regulating services the natural environment provides. From a regional perspective, the transformation of natural spaces in areas surrounding urban regions will directly impact on the services cities derive from the environment. Climate change will exacerbate this effect and reduce the ability of society to adapt. Urban areas are provided with fresh water, which availability and quality is affected by vegetation cover. Increased levels of impermeable surfaces (e.g. tar or concrete) restrict water infiltration to recharge groundwater storages and feed rivers, increase the volume of runoff and the absence of trees cannot slow down heavy rainfall, which makes urban areas highly vulnerable to flooding effects such as impacts on water supply and sanitation, infrastructure, damages to property, personal injury, livelihood impacts as well as increased road accidents and traffic congestion.

These changes to the urban landscape (such as tar, buildings, etc.) changes the reflectivity of the surface (surface albedo), leading to the so-called "heat island effect". Instead of reflecting sunlight, urban infrastructure absorbs the energy and heats up. In conjunction with increasing temperatures due to climate change, the temperature in urbanised areas would rise even further. With predicted increases in intense storm (especially hail storms) and flooding events due to climate change, the degradation of biomes, freshwater systems and reduced presence of vegetation cover will exacerbate water flooding. Besides the provision of services such as urban cooling, water supply, runoff mitigation and food production, ecosystems also moderate environmental extremes.

Further, the changes in land use and land cover within the CoJ and *inter alia* urbanisation, natural processes and run-off patterns, lead soil erosion. Soil erosion can negatively affect the level of plant regrowth and increase the sediment loads in streams and damns, for example.[32] The area within which the proposed mining project will be situated is relatively bare and exposed to soil erosion as well as wind erosion (tailings dams). Increasing temperatures and related occurrence of droughts, as predicted in future climate scenarios for the region, will contribute to increased wind erosion. Increased levels of dust could negatively impact on air quality and potentially transport dust-borne diseases.

Climate change is threatening economic, social and environmental well-being on a localised scale. In particular, human health and biodiversity in the CoJ will be most affected. The degradation and loss of ecosystem services will mostly likely affect lower income and vulnerable people disproportionately and has the potential to be a significant barrier to reducing poverty. The loss of natural systems through climate change will exacerbate social vulnerabilities and economic

[32] SANBI. 2013. Grasslands Ecosystem Guidelines: landscape interpretation for planners and managers. Compiled by Cadman, M., de Villiers, C., Lechmere-Oertel, R. and D. McCulloch. South African National Biodiversity Institute, Pretoria.

stability in the city region and could therefore further drive potential impacts on the proposed West Wits Project's social license to operate. The natural environment's level of resilience plays a vital role in climate change adaptation and in sustaining socio-economic well-being in urban areas (see Section 6.3 for details on indicators for social well-being). As such it forms part of this climate change impact assessment.

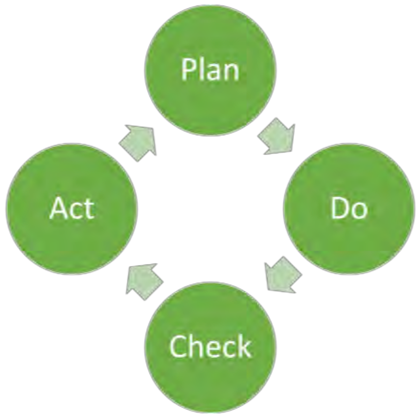
6.4.3 Resilience of the natural environment to climate change

Ecosystems are able to absorb some levels of disturbances (relating to both anthropogenic and other influences), i.e. are resilient. (Ecological) Resilience in this regard can be defined as "the capacity of a systems to absorb recurrent disturbances such as hurricanes or floods so as to retain essential structures, processes, and feedbacks" (Adger et al. 2005, p. 1036). The degradation of the natural environment in the CoJ due to, for example, pollution and urbanisation, the level of resilience of the natural environment to absorb disturbances has continuously decreased. Climate change will only exacerbate the existing ecosystem challenges, making them less able to withstand the climate changes that are predicted. This will make society and businesses operating within the CoJ highly exposed. Because the area in which the proposed mining project is situated is already highly disturbed and surrounded by residential areas, it is more prone to climate change risks such as floods and storms, health risks of employees and reduced air quality. At the same time, this provides opportunities for the mine. By implementing effective adaptation and rehabilitation measures, the site could be buffered from climate change risks, which the latter could result in potential large economic losses. Effective measures could also contribute to improved water quality, reducing dust formation and improve existing poor air quality conditions.

7 Climate Change Mitigation Options

Promethium Carbon's proposed climate change mitigation strategy for the proposed West Wits project is based on the outcomes of the risk and vulnerability assessment. South Africa's changing environmental regulations, energy and social landscapes are changing. These elements require that a climate change mitigation strategy be developed for the West Wits project.

The outline for the West Wits project's proposed mitigation strategy is based on the Plan-Do-Check-Act continual improvement framework (Figure 10).



Plan

Aspects to consider when planning for climate change mitigation:
→Develop and continuously monitor West Wits' GHG inventory;
→Identify associated with operational GHG emissions;
→Setting short, medium and life of mine emission reduction targets.

Do

The West Wits project's mitigation strategy has the following objectives:
→Identify continuous GHG emission reduction initiatives;
→Manage risks associated with GHG emissions;
→Ensure compliance with relevant policies and legislation.

Check

Monitoring, reporting and verification is important for:
→Measuring and tracking progress towards the achievement of GHG emission reduction targets;
→Measuring and tracking energy use in order to continuously consider energy efficiency options;
→Reporting on GHG emissions for stakeholders.

Act

Take actions to:
→Continually improve energy performance and the carbon management system;
→Reassess the impacts of existing and future policies and regulations;
→Ensure that the climate change policy is in line with the West Wits project's overall strategic goals;
→Adjust policies and indicators if desired results are not being met.

Figure 10: Plan-Do-Check-Act continual improvement framework.

8 Climate Change Adaptation Options

Because the natural environment is highly complex and highly unpredictable, adapting to the changing climate and developing strategies to respond to these uncertainties is challenging. The West Wits project is located within the current urban footprint of the City of Johannesburg. This makes climate adaptation critical to ensure both the continuation of operations as well as contributing to the resilience of the local community. In this regard the following are important with regards to the climate change adaptation related to the West Wits project.

- **Climate change risks and impacts are highly diverse and context-specific**. Planning for adaptation therefore needs to be driven across the various departments of the mine once operational, and incorporate appropriate local and external resources, expertise and knowledge to address potential climate risks. Climate change should form part of the West Wits project's risk assessment and risk management processes.
- **Timescales matter**. Climate change occurs in short to long-term timescales, with direct and indirect changes and impacts across the life of mine. As such the West Wits project's processes, structures and systems must consider the linkage of adaptation work across time scales and integrate continuous learning on adaptation. This is specifically relevant when considering the rehabilitation of the site once the mine come to end of life.
- **Uncertainty - climate changes and resultant risks and impacts are difficult to predict with certainty.** A framework must be developed with the appropriate flexibility to evolve with the changing climate risks. The West Wits project must move from a reactive approaches to climate impacts, to a pro-active approaches which include precautionary measures to be prepared for future latent risks Adaptation planning related to the West Wits project should consider items such as localised disaster risk management plans and/or early warning systems.
- **Decision-making processes are at the heart of effective adaptation**. The changing climate and its impacts on the West Wits project requires continuous and informed decision-making. This includes reviewing past trends, current conditions and anticipating future scenarios related to climate change on a continuous basis, also within the context of the surrounding social-economic character. In this regard systems and processes, which ensure anticipatory, flexible, locally contextualised decision-making are required. Collaboration with *inter alia* the directly impacted local community, the City of Johannesburg and the Minerals Council of South Africa on climate change adaptation could strengthen decision-making capabilities.
- **Underlying causes and drivers of vulnerability and economic growth** affect resilience to climate change. This may hinder the success of the implementation of adaptation actions. A holistic response to climate change risk and vulnerability management within the West Wits project is needed to align operational departments as well as link to other key stakeholders such as the Department of Environmental Affairs.
- **Climate Information Services** – Valuing and integrating local knowledge; interpreting scientific and meteorological information; and effective communication to all stakeholders are key to building resilience and adaptation to climate change impacts across the tourism sector.

9 Specialist Opinion

This study considered two perspectives in terms of climate change and the West Wits Project. The first was the impact of the project on climate change. The second was the impacts of climate change on the project. In both perspectives, the physical and transitional risks were considered.

In terms of the proposed West Wits Project's impact on climate change, the mine will generate emissions both through its direct operations, and there will be emissions associated with the mine's value chain. It is estimated that the emissions associated with the construction and the operation of the mine will be approximately 800 tonnes CO_2e per annum (scope 1 emissions) and 103 000 tonnes CO_2e per annum (Scope 2 emissions). The Scope 3 emissions of the mine amount to 130 000 tonnes CO_2e per annum.

The impact of the total West Wits Project's greenhouse gas inventory within a domestic context is therefore considered to be low-medium because the total lifetime inventory is expected to consume approximately 0.0031% of South Africa's carbon budget. The value of 0.0031% is above the low-materiality threshold (0.00013%) but below the medium-materiality threshold (0.013%) of South Africa's carbon budget.

In terms of the impacts of climate change on the project, there are key vulnerabilities related to the core operations and the value chain of the proposed project. The core operations are exposed, and highly sensitive to, increased temperatures, severe storms and variable rainfall patterns. These climatic changes will result in risks to the labour force, potential infrastructure damage as well as logistical disruptions.

With respect to the social and natural environment in which the mine would operate there are two key aspects to consider: the first is that the community surrounding the mining site is very vulnerable to climate change impacts. Secondly, land rehabilitation will play a critical role in restoring local ecosystem services. This will play an important role in addressing legacy mining issues which pose a number of risks to the local community.

In addition, the impacts on groundwater sources as well as the potential impact of infrastructure development or dust as a result of the proposed project, could be exacerbated by climate change. Hotter and drier conditions, coupled with the construction of infrastructure or the operational aspects such as transport, could increase the risk for increased dust.

To maintain its social license to operate we recommend that the impact of climate change on the mine's social environment be addressed in the mine's Social and Labour Plan. The Social and Labour Plan should include appropriate climate change adaptation actions focusing on health and resilience building, also considering the urban context of the mine, in terms of extreme weather events. In addition, efforts to re-establish regional vegetation as part of the mine closure process, to be integrated with planned housing development, will play an important role in ensuring community resilience.

Linked to the above is land rehabilitation. Land plays a critical role in post mine life sustainability. Pro-active planning for land restoration and rehabilitation, within the context of climate change, is critical to ensure the future integration of land into existing spatial economies and supporting sustainable development trajectories. Changing climatic parameters such as prolonged droughts and flash floods could constrain the land rehabilitation process. As such we recommend that the rehabilitation and mine closure plans must clearly address climate change risks and mitigation measures to optimise land for a variety of potentially viable post-mine life land uses.

In conclusion, the proposed West Wits Project will produce greenhouse gas emissions that will contribute to anthropogenic climate change and its ensuing impacts. The extent, duration and probability of the mine's greenhouse gas emissions impacts on climate change will be low-medium in the global context. Furthermore, the overall significance from the mine's single-source impact during construction and operational phases on global emissions and thus climate change, is rated as low to medium. This is however subject to the consideration of community vulnerability and long term rehabilitation within the context of further mine planning.

As with any issue of common concern to humanity, it is important that each actor makes an effort to minimise its own negative contribution to the issue so as to take a shared responsibility. This is particularly relevant to mining development such as the proposed West Wits Project.