APPENDIX X

Climate Change Assessment

GOLDER

DRAFT

REPORT

Climate Change Assessment: Application for EA and WUL for the Proposed Grootegeluk Turfvlakte Expansion Project at Grootegeluk Coal Mine near Lephalale, Limpopo Province

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Executive Summary

This climate change assessment was undertaken as part of the environmental impact assessment ("EIA") process for the proposed Grootegeluk Turfvlakte Expansion Project ("Turfvlakte Project" or the "Project"), located near the town of Lephalale, in the province of Limpopo.

Climate Change Assessment

The Turfvlakte Project is located within an area classified as semi-arid, dry, and hot in terms of the Köppen climatic classification (Hatfield Consultants and AHT Group AG, 2020). Currently, average monthly temperatures are approximately 21.2°C, with a low of 14.3°C in June and a high of 25.3°C in January (World Bank, 2020). Average annual rainfall is approximately 466 mm, with an average monthly low of 2.6 mm in July and a high of 87.8 mm in January.

With climate change, monthly average temperatures are projected to increase by between 1.08°C and 1.25°C in the short term (2020 to 2039) and by between 1.71°C and 3.1°C in the medium term (2040 to 2059). The number of hot days (>35°C) are projected to increase by between 19 days and 22 days in the short term, and by between 36 days and 59 days in the medium term. Annual average rainfall is projected to decrease by between 3.8 mm and 35 mm in the short term, and by between 46.5 mm and 74.1 mm in the medium term. The number of extreme rainfall days are projected to increase marginally by between 0.05 days and 0.68 days in the short term. In the medium term, the number of extreme rainfall days may either decrease by 1.1 days or increase by 0.61 days.

The Turfvlakte Project is located within the Limpopo River Basin, which experiences extremely variable climatic and hydrological regime characterised by floods and droughts. Rainfall is highly variable within and between seasons, with a short but intense rain season.

A qualitative assessment was undertaken to determine the potential impact of the projected changes in climate on the vulnerable sectors in Lephalale. This included the following sectors:

- Agriculture
- Livelihoods and settlements
- Aquatic and terrestrial biodiversity
- Water supply
- Human health

In addition, a qualitative assessment was undertaken to determine the potential impact of the projected changes in climate on the vulnerable components of the Turfvlakte Project. This included the following components:

- Open pits
- Haul roads and ramps
- Topsoil dump
- Employees and contractors
- Beneficiation plants (at the Grootegeluk Coal Mine)
- Grootegeluk Pit

Table E.1 presents a summary of the potential impacts of climate change on the vulnerable sectors in Lephalale and the vulnerable components of the Turfvlakte Project, with and without mitigation.

Table E.1: Summary of potential climate change impacts on vulnerable sector/components

Vulnerable sector/ component	Potential Impact	Significance without mitigation	Significance with mitigation
1. Lephalale			
Livelihoods and settlements	Increased temperatures and hot days, together with decreased rainfall, can lead to decreased crop areas, crop yield, and crop quality, as well as livestock infertility, productivity losses, and even mortality.	Moderate	Moderate
Livelihoods and settlements	Increased temperatures and hot days, together with decreased rainfall, can lead to decreased crop yields and even crop losses.	High	Moderate
Aquatic and terrestrial biodiversity	Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration, drought conditions, and the frequency and intensity of wildfires, which can impact negatively on the terrestrial ecosystems.	Moderate	Moderate
Aquatic and terrestrial biodiversity	Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration, reduced runoff, and drought conditions, which can impact negatively on aquatic ecosystems (i.e. rivers, pans, and wetlands) in Lephalale.	High	High
Water supply	Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration and the increase in frequency and severity of droughts. This can reduce water availability in a region which is already known to be water scarce.	Moderate	Moderate
Human health	Increases in average annual temperatures and number of hot days (>35°C) can increase risk of people living in Lephalale, especially those with underlying conditions, suffering from heat stroke and dehydration, which can adversely affect their health and well-being.	Moderate	Moderate
Human health	Variations in climatic conditions, such as temperature, rainfall patterns, and humidity, can increase malaria transmission, which can adversely affect the health and well-being of people living in Lephalale.	Moderate	Moderate
2. Turfvlakte Project			
2.1 Operational Phase			

Vulnerable sector/ component	Potential Impact	Significance without mitigation	Significance with mitigation
Open pits	A decrease in average annual rainfall will reduce direct rainfall onto the open pits, surface runoff, and groundwater infiltration, thereby reducing pit dewatering requirements.	Positive	Positive
Haul roads and ramps	An increase in the number of extreme rainfall days can make access roads temporarily impassable, impacting negatively on the transport of ROM coal from the pits to the beneficiation plants at Grootegeluk Coal Mine.	Low	Low
Topsoil dump	An increase in the number of extreme rainfall days can lead to increased erosion of the exposed soil stockpiles, and sedimentation of the stormwater system or receiving environment.	Low	Low
Employees and contractors	An increase in average monthly temperatures and number of hot days can increase the risk of employees suffering from heat stroke and dehydration, which can adversely affect their health and well-being.	Moderate	Low
Employees and contractors	Variations in climatic conditions, such as temperature, rainfall patterns, and humidity, can increase malaria transmission, which can adversely affect the health and well-being of employees and contractors.	Moderate	Low
Beneficiation plants	A decrease in average annual rainfall will reduce direct rainfall onto the open pits, surface runoff, and groundwater infiltration, thereby reducing the availability of pit water for the beneficiation plants at Grootegeluk Coal Mine.	Moderate	Low
Grootegeluk Pit	Marked increases in daily or seasonal temperatures will increase the rate of oxidation, thereby increasing exothermic reactions and the risk of the coal discards in the backfill igniting or burning (spontaneous combustion)	Moderate	Low
2.2 Closure Phase			
Rehabilitated mining areas	A decrease in average annual rainfall, coupled with an increase in average monthly temperatures and evaporation rates, will reduce the water availability to the plants used in rehabilitation of mining areas. This can impact negatively on the establishment of vegetation on these areas, and their stability in the long-term.	Moderate	Low

The recommended adaptation measures are listed below:

- **Lephalale:**

  - Implementing a community awareness program to educate communities about climate change, the predicted changes in temperature and rainfall, and best practice methods for reducing crop and livestock losses
  - Develop and implement a community awareness program to educate the local community about water conservation and demand management
  - Develop and implement a rainwater harvesting programme to provide dwellings without potable water inside with a concrete rainwater tank
  - Develop and implement an onsite rehabilitation programme to rehabilitate areas disturbed by construction and mining activities
  - Develop and implement an alien invasive species control programme to manage the spread of alien invasive species onsite
- **Turfvlakte Project:**
  - Limit the area in the immediate vicinity of the open pits that will be graded to drain towards the open pits
  - Construction of diversion channels and ditches to direct non-contact water away from the open pits
  - Use of pit floor sumps to pump pit water to Grootegeluk Coal Mine where it will be used for dust suppression and process water
  - Ensure that haul roads and ramps are maintained in good condition by attending to potholes, corrugations, and stormwater damage as soon as these develop
  - Construction of upslope diversion berms to divert stormwater runoff around the topsoil dump
  - Construction of conduits to direct runoff from the topsoil dump to a stormwater outfall point
  - Develop and implement an employee health awareness program to educate Exxaro's employees and contractors about the importance of drinking water and identifying the signs of early signs of heat stroke
  - Monitor malaria incident reports
  - If local Malaria incidents are reported, implement fogging and spraying at the mine during the wet season (September to April)
  - Develop and implement an employee health awareness program to educate Exxaro's employees and contractors about Malaria and preventative measures
  - Develop a water conservation/water demand management plan for the Turfvlakte Project and incorporate it into the existing water conservation/water demand management plan for Grootegeluk Coal Mine for implementation
  - Where possible, cover each bench to minimise the exposed surface area for exothermic reactions and to prevent the ingress of oxygen and moisture
  - Annual thermographic surveys of the pit backfill to identify 'hotspots' for signs of spontaneous combustion

- Post-closure monitoring of the re-vegetated areas on an annual basis. If required, apply new topsoil, fertilise, reseed/replant, and water areas where plants have been washed away or struggling to become established

Abbreviations

Abbreviation	Description
CO_2	Carbon dioxide
CMIP5	5th Phase of the Coupled Model Intercomparison Project
CSIR	Council for Scientific and Industrial Research
EIA	Environmental impact assessment
Exxaro	Exxaro Resources Limited
GHG	Greenhouse gas
$GtCO_2e$	Gigatonnes carbon dioxide equivalent
Golder	Golder Associates Africa (Pty) Ltd.
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
Mtpa	Million tonnes per annum
NDC	Nationally Determined Contributions
RCP	Representative Concentration Pathways
ROM	Run-of-mine
Project site	Turfvlakte 463 LQ
SHEQ	Safety, health, environment, and quality
Turfvlakte Project	Grootegeluk Turfvlakte Expansion Project

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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd. (“Golder”) were appointed by Exxaro Resources Limited (“Exxaro”) to undertake a climate change assessment as part of the environmental impact assessment (“EIA”) process for the proposed Grootegeluk Turfvlakte Expansion Project (“Turfvlakte Project” or the “Project”), located near the town of Lephalale, in the province of Limpopo.

The scope of work of this assessment was as follows:

- Briefly describe the current climate in Lephalale
- Briefly describe previous extreme weather events which have affected Lephalale
- Determine the projected changes in climate in Lephalale in the short term (2020 to 2039) and medium term (2040 to 2059), under low-medium (RCP4.5) and high (RCP8.5) emissions scenarios. This includes changes in average temperatures, number of very hot days, average rainfall, and extreme rainfall days
- Identify and describe the components of the Turfvlakte Project that are the most vulnerable to the projected changes in climate
- Undertake a qualitative assessment of the potential impacts of these projected changes on the vulnerable sectors in Lephalale economy, as well as the vulnerable components of the Turfvlakte Project
- Identify measures to reduce the vulnerability of the Turfvlakte Project to the projected changes in climate

2.0 BACKGROUND

2.1 Project Location

The Turfvlakte Project is located within the Lephalale Local Municipality, which falls within the boundaries of the Waterberg District Municipality, in the Limpopo Province.

More specifically, the Turfvlakte Project is located on the eastern portion of the farm Turfvlakte 463 LQ (“Project site”) directly south of and within the existing Mining Right of Grootegeluk Coal Mine (Figure 1).

The Eskom Medupi Power Station is located to the south and privately-owned land to the east and southeast of the Project site. The Matimba Power Station is located approximately 3 km to the east of the Project site, Marapong approximately 5 km to the northeast, and Lephalale approximately 30 km southeast.

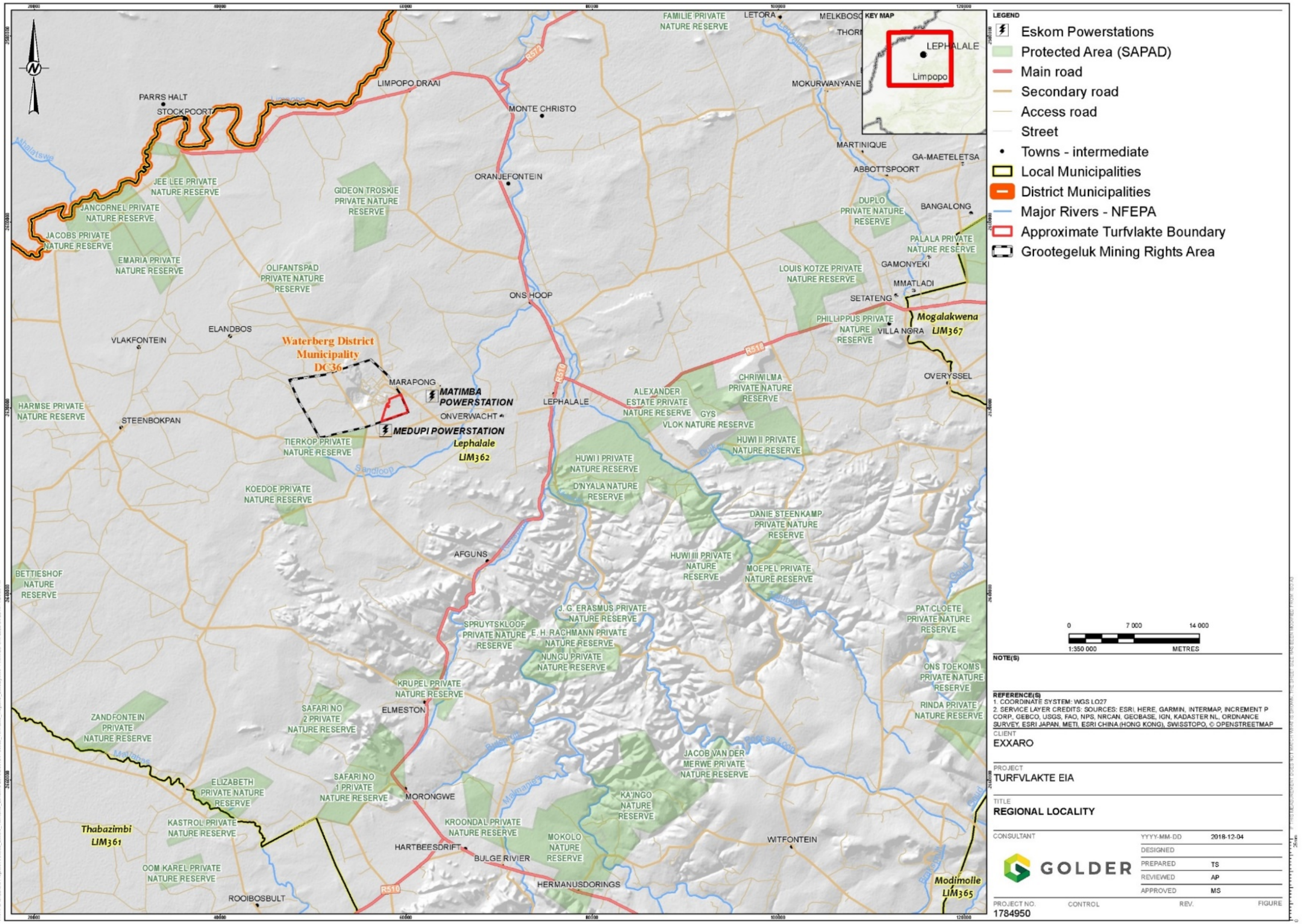


Figure 1: Regional locality of the Turfvlakte Project

2.2 Project Description

Exxaro is proposing to develop the Turfvlakte Project in order to augment the current production from Grootegeluk Coal Mine during periods when the main pit production is under pressure

Products

The Turfvlakte Project will mainly produce thermal coal for the local market.

Mining Method

The topsoil from the open pit areas will be stripped prior to mining and will be stored on a dedicated topsoil stockpile located in the north western section of the Project site. The overburden (material that lies above the coal, such as the hards and softs) generated during the creation of the box cuts (first cut into the overburden to access the coal and interburden) will be stockpiled on the existing Dump 6 at the Grootegeluk Coal Mine. The interburden (material that separates the coal seams within strata) will be transported with the coal to the existing beneficiation plants at the Grootegeluk Coal Mine for further beneficiation.

Removal of topsoil, overburden, interburden, and coal will be done by means of draglines, bucket wheel excavators or bowl scrapers.

Production Rates and Mining Schedule

The preferred option is to mine Pit 1 and then Pit 2 to produce 1.5 million tonnes per annum ("Mtpa") run of mine ("ROM") coal over a period of 16 years. Pit 1 will be mined from year 1 to 11, while Pit 2 will be mined form year 12 to 16. Mining operations will be undertaken 24 hours a day, six (6) days a week.

The alternative option is to mine the two pits concurrently, with Pit 1 being mined from year 1 to 4 and Pit 2 from year 1 to 7, to produce 3 Mtpa ROM coal over a period of 7 years. This option was not considered further in this assessment as the mining schedule, due to the short duration, does not materially affect the greenhouse gas ("GHG") emissions. This is because it is the quantity of coal and not necessarily the rate at which it is mined that determines the emissions.

Main Infrastructure:

Table 1 presents a brief description of the main infrastructure at the Turfvlakte Project. The proposed layout of the Project is shown in Figure 2. For contextual purposes, the location of the associated infrastructure at Grootegeluk Coal Mine is shown in Figure 3.

Table 1: Main infrastructure at the Turfvlakte Project

Infrastructure	Description
Open pits	The opencast operations will consist of two pits, namely Pit 1 and Pit 2. Pit 1 will be 158 ha in extent and will be 88 m deep, while Pit 2 will be 64 ha in extent and 109 m deep.
Roads	The Project site will be accessed via the existing tarred access roads to the Grootegeluk Coal Mine. New haul roads will be constructed at the Project site to tie into the existing haul roads at the Grootegeluk Coal Mine. The haul roads will be gravel surfaced and connect Pit 1, Pit 2, the infrastructure laydown area (also referred to as the 'servitude for infrastructure'), and topsoil stockpile at the Project site with Dump 6 and the rest of the operational areas at the Grootegeluk Coal Mine.
Servitude for infrastructure	The servitude for infrastructure will be 18 ha in extent and will serve as an area for safe parking, offices, and equipment storage.

Infrastructure	Description
Storm water management	Cut-off berms and earth canals will be located upstream of the infrastructure areas to divert the clean water run-off around the dirty infrastructure areas. The contaminated run-off will be collected in concrete-lined channels that will connect with the existing storm water management system at the Grootegeluk Coal Mine via the pit pumping system. Pit water will then be pumped to the relevant water storage facilities for reuse at the Grootegeluk Coal Mine.
Water supply	Potable water will be pumped from the existing potable water system at the Grootegeluk Coal Mine.
Sewage treatment	Sewage effluent will be transferred to the existing sewage treatment facilities at the Grootegeluk Coal Mine for treatment.
Electricity supply	Electricity will be supplied directly from the main Eskom 132/33 kV substation, as well as the proposed GG1/GG2 33 kV switching station at the Grootegeluk Coal Mine.

2.3 Project Timeframes

The construction phase will likely commence in 2022 and last for approximately one year. The operational phase will be initiated after the completion of construction and will last approximately sixteen years (2023 to 2038) – see Figure 4. The closure phase will last approximately one year (2039).

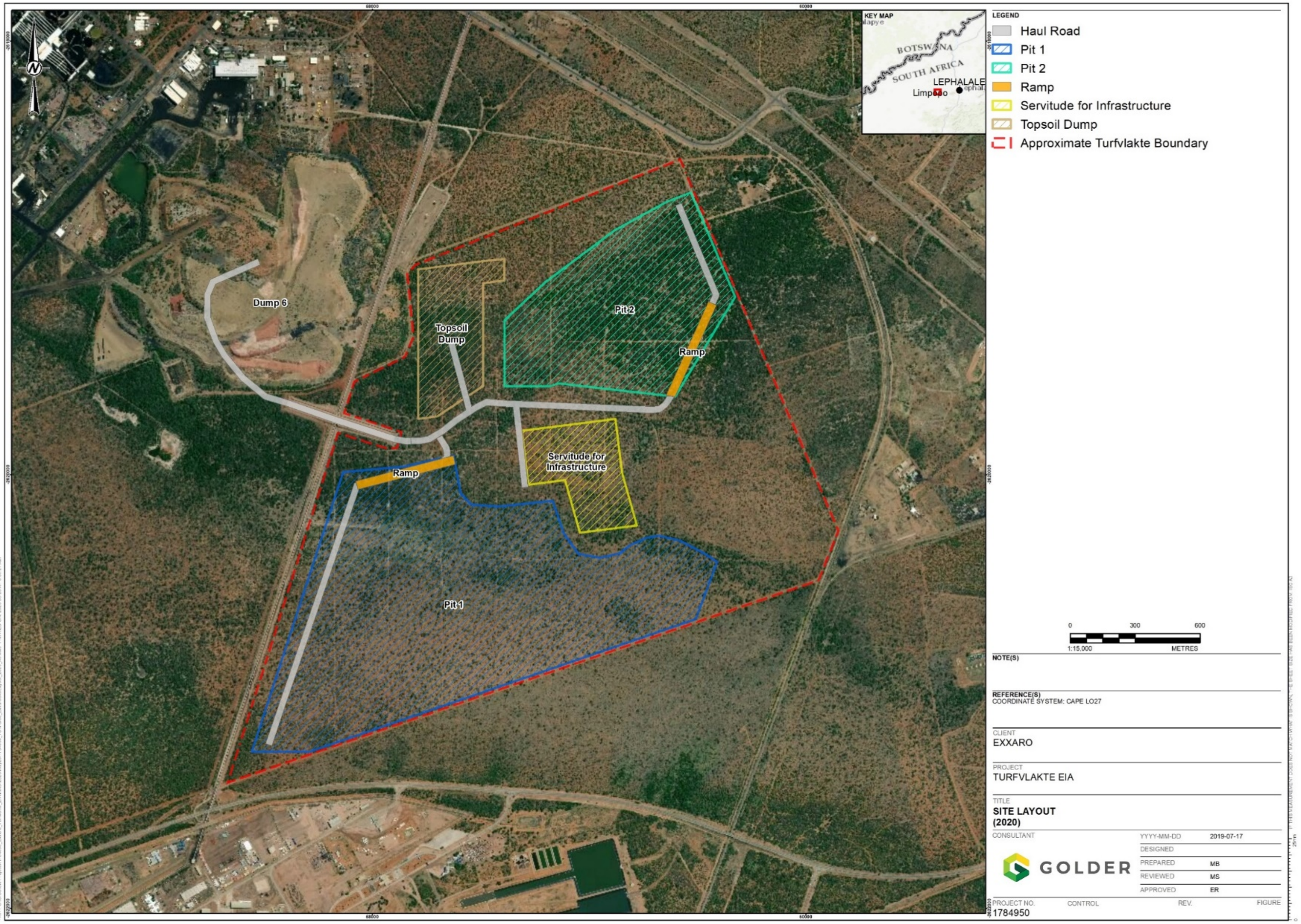


Figure 2: Proposed layout of the Turfvlakte Project

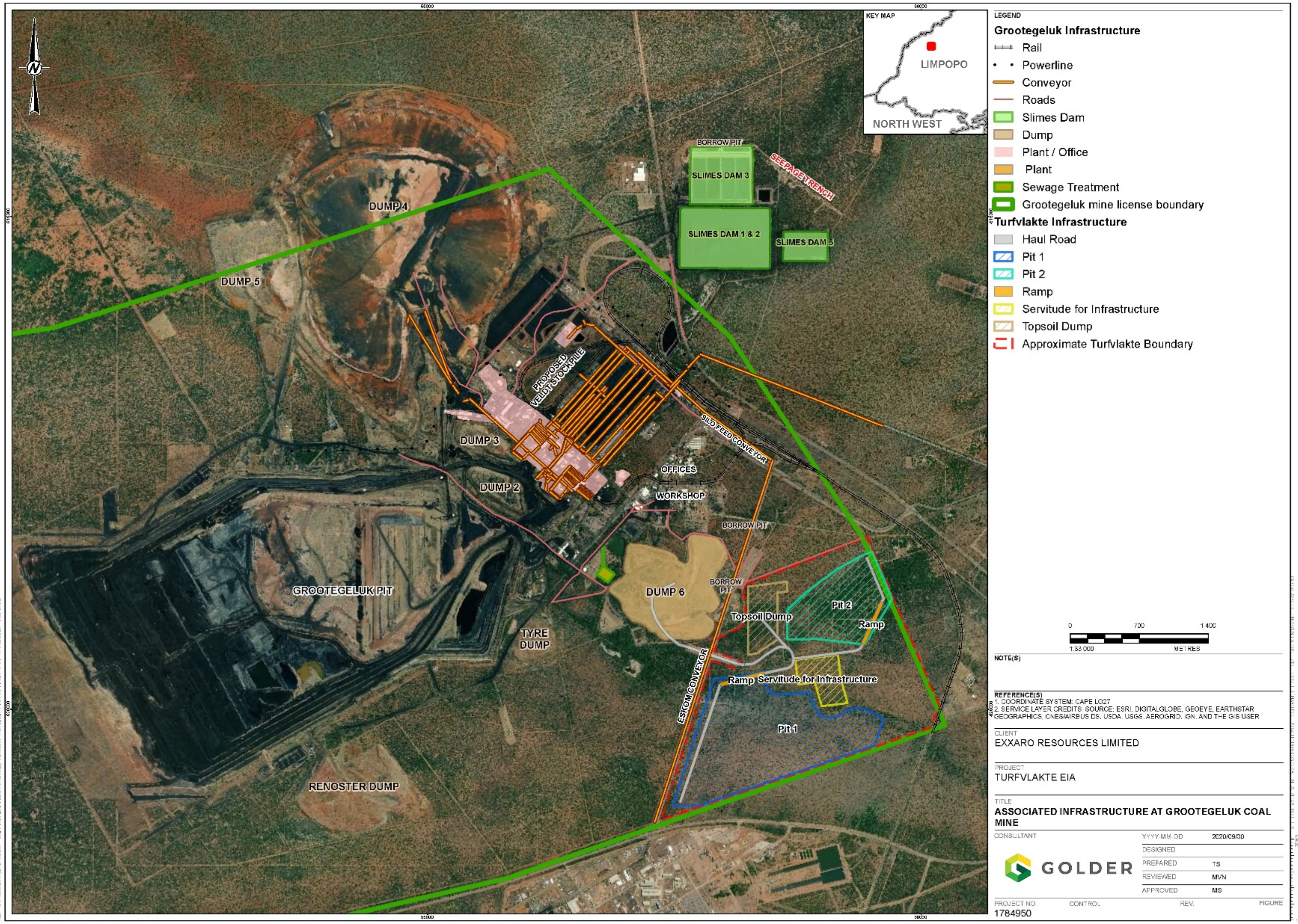


Figure 3: Location of associated infrastructure at the Grootegeluk Coal Mine

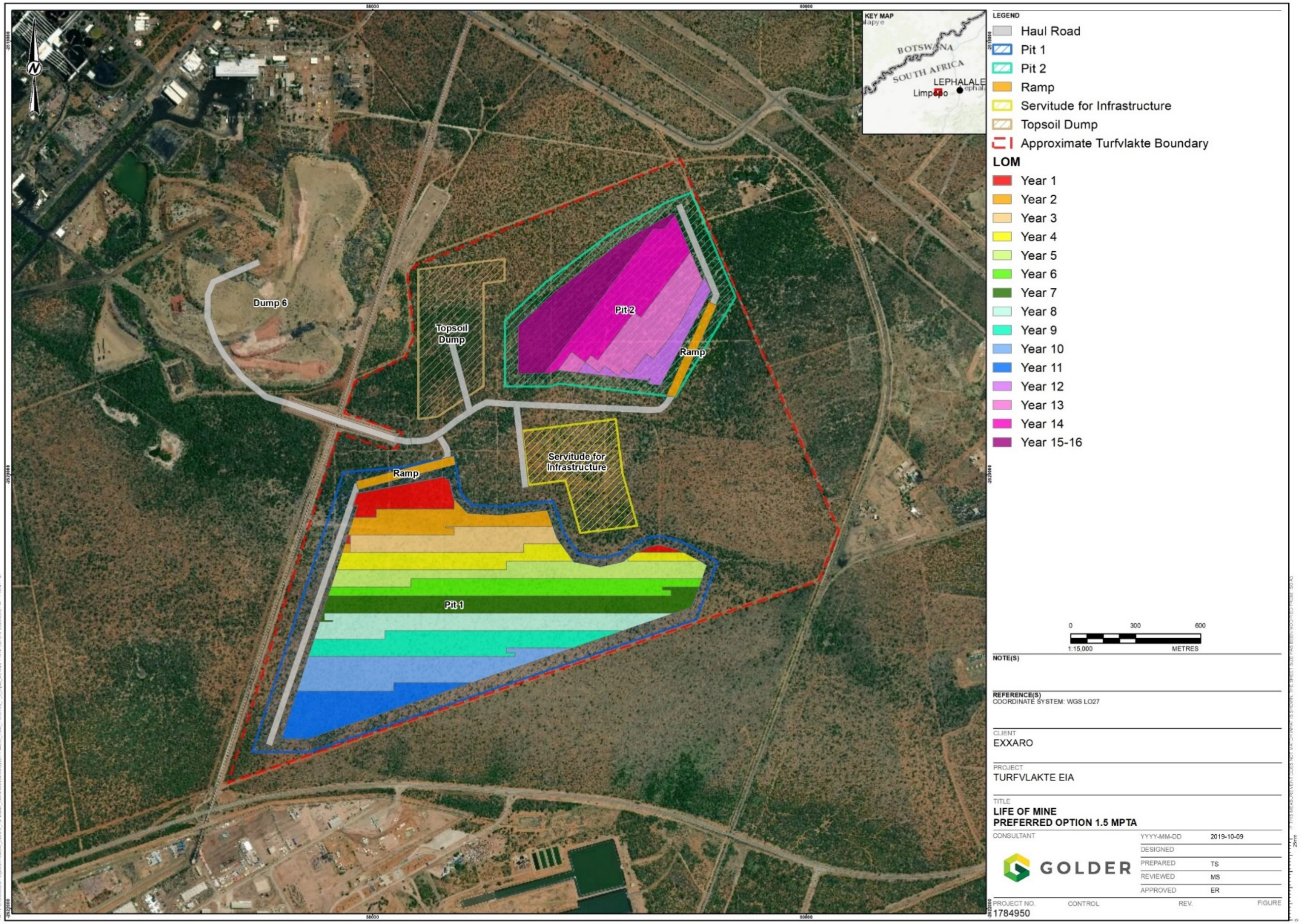


Figure 4: Proposed mining schedule of the Turfvlakte Project

3.0 REGULATORY FRAMEWORK

This following section presents a broad overview of framework regulating climate change globally and in South Africa. It is not intended to be a comprehensive review of all legislation, policies, and guidelines, but only those which are most applicable to the project.

3.1 South African Regulatory Framework

South Africa does not currently have any Acts or Gazetted Notices regulating climate change. There is the Climate Change Bill, 2018, which was published for public comment under General Notice 580 in Government Gazette No. 41689 of 8 June 2018. This Bill has however, not been gazetted and is not yet in effect. In the absence of climate change-specific legislation, South Africa's response to climate change is largely guided by National Climate Change Response White Paper.

3.1.1 Climate Change Bill, 2018

The objectives of the Climate Change Bill, 2018 are to (DEA, 2018):

- Provide for the coordinated and integrated response to climate change and its impacts by all spheres of government in accordance with the principles of cooperative governance
- Provide for the effective management of inevitable climate change impacts through enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to building social, economic, and environmental resilience and an adequate national adaptation response in the context of the global climate change response
- Make a fair contribution to the global effort to stabilise GHG concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe and in a manner that enables economic, employment, social and environmental development to proceed in a sustainable manner

In terms of GHG emissions and removals, the Minister must:

- Determine a national GHG emissions trajectory for South Africa which is binding on all organs of state in all spheres of government, and all persons to the extent applicable
- Determine sector emissions targets for GHG emitting sectors and sub-sectors. This includes the preparation of a sector emissions reduction plan which sets out how the relevant sector and sub-sector will meet the sector emissions targets within five years of the publication of the said targets
- Determine a GHG emissions threshold for the purposes of determining persons that will be allocated a carbon budget. A person to whom a carbon budget has been allocated is obliged to:
  - Comply with the carbon budget
  - Develop and implement an approved GHG mitigation plan
- Develop and implement a plan to phase down or phase out the use of synthetic GHGs

3.1.2 National Climate Change Response White Paper, 2012

The National Climate Change Response White Paper, 2012 presents South Africa's "*vision for an effective climate change response and the long-term, just transition to a climate-resilient and lower-carbon economy and society*" (DEA, 2012).

The main objectives of the White Paper are to:

1) Effectively manage inevitable climate change impacts through interventions that build and sustain South Africa's social, economic, and environmental resilience and emergency response capacity
2) Make a fair contribution to the global effort to stabilise GHG concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social, and environmental development to proceed in a sustainable manner

The White Paper acknowledges that South Africa has relatively high emissions per capita or by GHG intensity (emissions per unit gross domestic product). This energy intensity is largely due to coal-intensive electricity generation, and mining, industry, and transport sectors.

The White Paper recognises that South Africa's GHG emissions could grow rapidly, by as much as four-fold, by 2050 if left unchecked. In contrast to other developing countries, South Africa has limited opportunities to reduce emissions by reducing deforestation as land use change only accounts for 5% of the country's total GHG emissions. The White Paper focuses on electricity generation, mining, industry, and transport sectors as this is where the largest emission reduction potential exists. The main opportunities for mitigation include energy efficiency, demand management, and transition to a less emissions-intensive energy mix.

The White Paper supports policy decisions on new infrastructure investments which consider climate change impacts to avoid being locked into emissions intensive technologies in the future. However, given the current economic lifecycle of existing infrastructure, the most viable short-term mitigation options are energy efficiency and demand side management, coupled with increasing investment in a renewable energy programme. The White Paper also recognises that there are sectors of economy which are emissions-intensive and/or trade-exposed that are vulnerable impacts of climate change regulation, the application of trade barriers, a shift in consumer preferences, and a shift in investor priorities. This includes sectors, such as iron and steel, non-ferrous metals, chemicals and petrochemicals, mining and quarrying, machinery, and manufacturing.

3.1.3 Limpopo Climate Change Response Strategy, 2016-2020

The Limpopo Province, in which the Turfvlakte Project is located, has developed the Limpopo Climate Change Response Strategy, 2016-2020. The vision of this strategy is a "*a low carbon economy province that is resilient to impacts of a changing climate through concerted implementation of policies and programs that minimize greenhouse gas emissions, socio-economic threats and environmental risks while maximizing the benefits from opportunities which may arise from climate change.*" (Limpopo DEDET, 2016).

The strategy identifies and prioritises adaptation measures in following sectors:

- Agriculture
- Livelihoods and settlements (rural and urban)
- Ecosystem (terrestrial and aquatic)
- Water supply
- Human health

The strategy also identifies and prioritises mitigation measures in the following clusters:

- Renewable energy and energy efficiency
- Waste reduction and resource efficiency
- Transport and land use management
- Industrial emission reduction through cleaner production and resource efficiency

- Agricultural sector emission reduction
- Communication, education, and public awareness

In terms of coal mining, the strategy recognises that mining is the main driver of the provincial economy, which is important for both employment creation and economic growth. The strategy identifies access to freshwater as a major challenge, which is predicted to become worse in future, with potentially devastating effects on several sectors, including mining. Consequently, the strategy supports initiatives to improve water efficiency in the mining sector.

3.2 Global Regulatory Framework

South Africa is a signatory to several climate change agreements which are discussed in more detail in the sections to follow.

3.2.1 United Nations Framework Convention on Climate Change, 1994

The UNFCCC came into force on 21 March 1994 (UNFCCC, 2020a). Currently, there are 197 parties to the UNFCCC. South Africa ratified the convention on 29 August 1997.

The aim of the UNFCCC is to stabilise greenhouse gas concentrations at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.

The UNFCCC recognises that economic development is critical to developing countries, and that economic progress will be difficult to achieve even without complications associated with climate change. As such, the UNFCCC accepts that the share of GHG emissions produced by developing countries will increase in the future. For UNFCCC to achieve its aim, support will need to be provided to developing countries so that they are able limit emissions in ways that will not hinder their economic progress.

3.2.2 Kyoto Protocol, 2005

The Kyoto Protocol came into force on 16 February 2005 (UNFCCC, 2020b). Currently, there are 192 Parties to the Kyoto Protocol. South Africa ratified the Kyoto Protocol on 31 July 2002.

The purpose of the Kyoto protocol is to operationalise the UNFCCC by committing industrialised countries to limit and reduce GHG emissions in accordance with agreed individual targets. The Kyoto Protocol only binds developed countries, and places a heavier burden on them, because it recognises that they are largely responsible for the current high levels of GHG concentrations in the atmosphere.

The Kyoto Protocol comprises of the following annexes:

- **Annex 1:** Developed countries and countries with economies in transition have binding emission reduction targets. These targets add up to an average 5% emission reduction compared to 1990 levels over the five-year period 2008–2012 (the first commitment period)
- **Annex II**: Developed countries which are required to provide financial resources to enable developing countries to undertake emissions reduction activities
- **Non-Annex 1:** Developing countries with no binding emission reduction targets. South Africa is listed as a Non-Annex 1 country

One of the most important elements of the Kyoto Protocol was the establishment of flexible market mechanisms, to allow countries that are unable to meet their targets through national measures, to meet the targets by way of three market-based mechanisms. This includes:

- International Emissions Trading (between Annex 1 and 2 country)
- Joint implementation (between Annex 1 and 2 country)
- Clean Development Mechanism (between Annex 1 or 2 country and Non-Annex 1 country)

These mechanisms are meant to encourage GHG abatement where it is most cost-effective, such as in developing countries. The premise is that it does not matter where emissions are reduced, so long as they are removed from the atmosphere. The added benefit of these mechanisms is that they encourage the private sector to cut and hold steady GHG emissions at a safe level, to stimulate green investment in developing countries, and make leap-frogging (skipping the use of older, dirtier technology for newer, cleaner infrastructure and systems) more economical.

3.2.3 Copenhagen Accord, 2009

The Copenhagen Accord came out of COP15 (2009), which was held in Copenhagen, Denmark. This non-binding agreement was signed by 141 countries, including South Africa. One of the main elements of the Accord was requirement for countries to pledge to non-binding emission reduction targets. In accordance with this requirement, South Africa pledged, subject to receiving international support, to (DEA, 2010):

- Reduce GHG emissions by 34% by 2020 compared to business-as-usual
- Reduce emissions by 42% by 2025 compared to business-as-usual

3.2.4 Paris Agreement, 2016

The Paris Agreement came into force on 4 November 2016 (UNFCCC, 2020c). Currently, there are 125 Parties to the Agreement. South Africa signed the Agreement on 22 April 2016.

The purpose of the Agreement is to strengthen the global response to the threat of climate change, reaffirming the goal of limiting global temperature increase to well below 2°C, while pursuing efforts to limit the increase to 1.5°C. The agreement also aims to:

- Reach global peaking of GHGs as soon as possible, recognising that peaking will take longer for developing countries
- Conserve and enhance, as appropriate, sinks and reservoirs of GHGs
- Recognise possibility of voluntary cooperation/market- and non-market-based approaches
- Establish a global goal on adaptation to enhance adaptive capacity, strengthen resilience and reduce vulnerability to climate change
- Enhance understanding, action, and support on a cooperative and facilitative basis with respect to loss and damage associated with the adverse effects of climate change
- Reaffirm the obligation of developed countries to support the efforts of developing countries, while also other countries to make voluntary contributions
- Enhance climate change education, training, public awareness, public participation, and public access to information
- To undertake a “global stocktake” in 2023 and every 5 years thereafter, to assess collective progress toward achieving the purpose of the Agreement

In addition, the Agreement also requires all Parties to submit their Intended Nationally Determined Contributions (“INDCs”), which outline a country’s proposed mitigation and adaptation measures for the period post-2020.

Upon ratification, an INDC becomes a Nationally Determined Contributions (“NDC”). Parties are also required to communicate their NDCs every 5 years and provide information necessary for clarity and transparency.

4.0 BASELINE CLIMATIC CONDITIONS

The following section presents an overview of baseline climatic conditions of the central region in which the Turfvlakte Project is located.

The central region falls within an area classified as semi-arid, dry, and hot in terms of the Köppen climatic classification (Hatfield Consultants and AHT Group AG, 2020). In the interior of Southern Africa, there is a strong rainfall gradient from east to west, with total rainfall decreasing westward. As a consequence, the climate of the central region is generally semi-desert with low and variable rainfall.

The central region experiences two distinct seasons with a wet season from November to April and dry season from May to October. The wet season occurs when the Inter-Tropical Convergence Zone (“ITCZ”) moves south, bringing rainfall, while the dry season occurs when the ITCZ retreats northward (Figure 5). Rainfall in the central region generally occurs in the wet season in the form of thunderstorms.

Due to altitude and the lack of ocean influence, the central region generally experiences large daily and seasonal temperature ranges. Frost is a frequent occurrence in winter and snow is common above 1 500 meters above sea level.

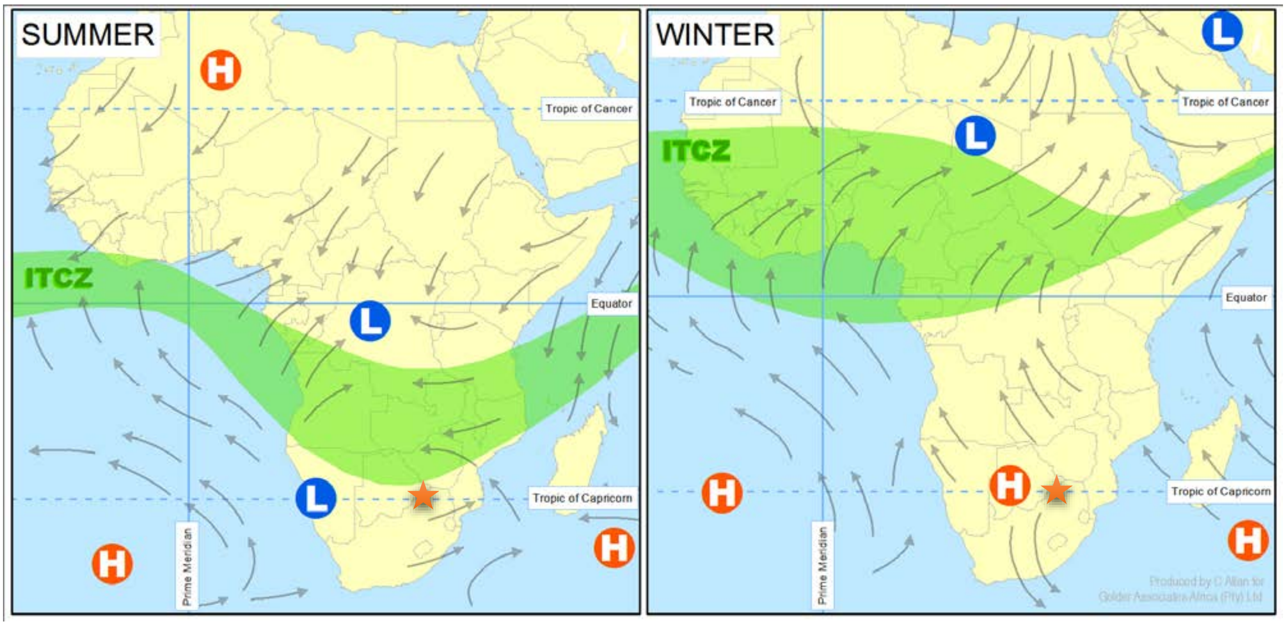
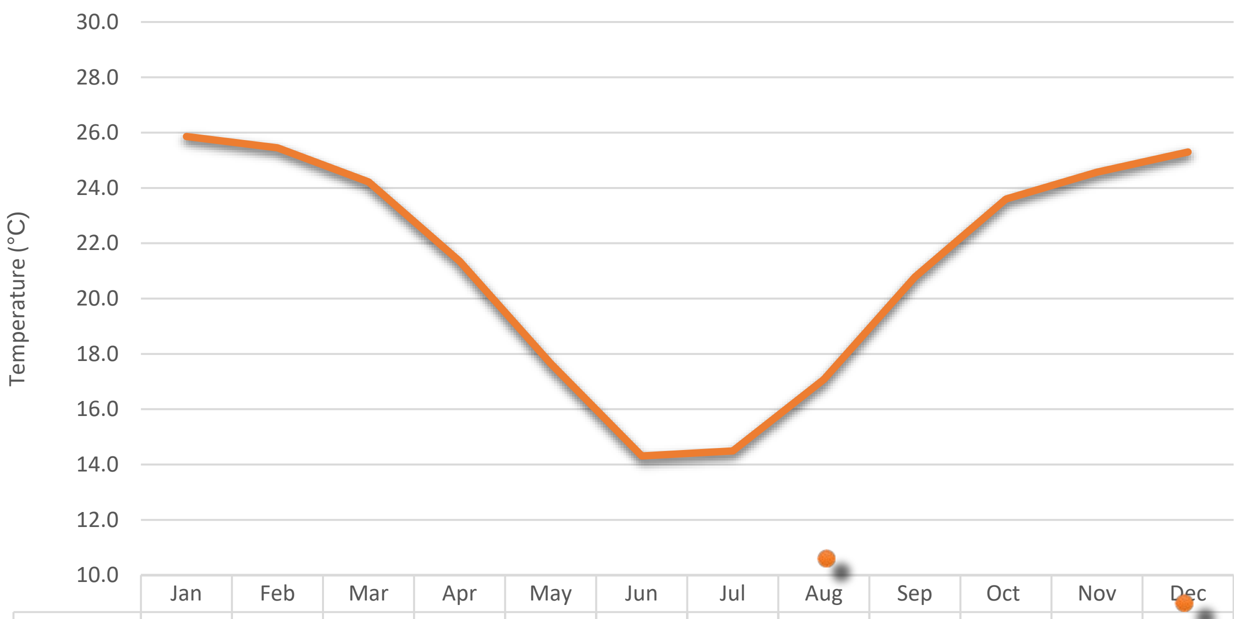


Figure 5: Seasonal circulation patterns affecting the regional climate

4.1 Temperature

Temperatures in the central region follow a distinct seasonal cycle, with the coolest months in the winter, from June to August, and the higher temperatures in early summer, from late November to early December (Hatfield Consultants and AHT Group AG, 2020). In the summer months, average daily temperatures of 40°C are not uncommon, while in the winter temperatures, temperatures can drop as low as 0°C at night.

Figure 6 presents the average monthly temperatures in Lephalale from 1901 to 2016 (World Bank, 2020). Average monthly temperatures are approximately 21.2°C, with a low of 14.3°C in June and a high of 25.3°C in January.



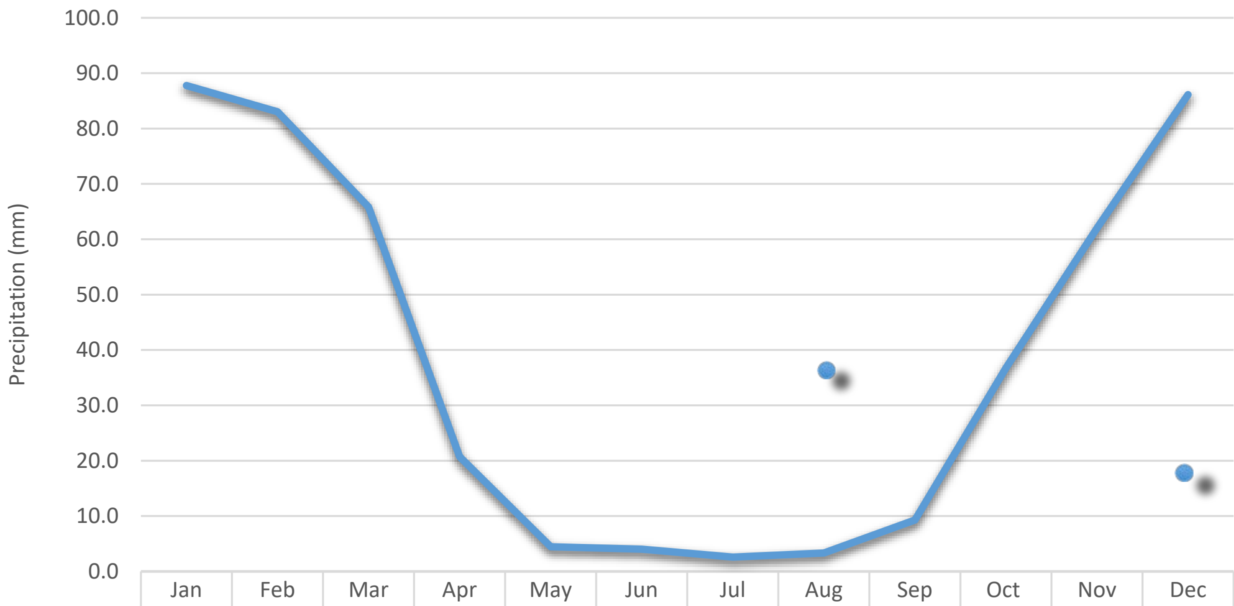
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	25.9	25.5	24.2	21.4	17.7	14.3	14.5	17.1	20.8	23.6	24.6	25.3

Figure 6: Average monthly temperatures in Lephalale from 1901 to 2016 (World Bank, 2020)

4.2 Rainfall

The central region receives relatively low rainfall, with most of the rainfall occurring within a short window, during the summer months (between October and April) (Hatfield Consultants and AHT Group AG, 2020). Rainfall events are highly infrequent and intense, and usually associated with convective thunderstorms.

Figure 7 presents the average monthly rainfall in Lephalale from 1901 to 2016 (World Bank, 2020). Total average rainfall is approximately 466 mm, with a low of 2.6 mm in July and high of 87.8 mm in January.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	87.8	83.0	65.8	20.7	4.5	4.0	2.6	3.3	9.3	36.8	62.0	86.1

Figure 7: Average monthly rainfall in Lephalale from 1901 to 2016 (World Bank, 2020)

Due to the flat topography, high temperatures, high rates of evaporation, and low humidity, rainfall generally has to exceed 20 to 30 mm in a single event before runoff can occur (Hatfield Consultants and AHT Group AG, 2020). Run-off therefore rarely reaches drainage channels.

4.3 Evapotranspiration

In general, evapotranspiration in the central region is high in comparison to rainfall, with values ranging from 1 500 to 2 000 mm/yr (Hatfield Consultants and AHT Group AG, 2020). As a result, there is a net moisture loss through evapotranspiration in the central region.

4.4 Extreme Weather Events

The Turfvlakte Project is located within the Limpopo River Basin, which experiences extremely variable climatic and hydrological regime characterised by floods and droughts (Lindevall, 2020). Rainfall is highly variable within and between seasons, with a short but intense rain season. The high rates of evapotranspiration also reduce the amount of rainfall that contributes to river flow or groundwater recharge. As a result, only two out of every five agricultural seasons within the Limpopo River Basin produce crop yields.

While the low-lying areas of central and southern Mozambique are generally the most affected by floods and droughts in the Limpopo River Basin, having suffered 53 natural disasters in the last 45 years, the central region in which the Turfvlakte Project is located has also been affected. Figure 8 presents a summary of past extreme weather events which have affected the central region.

1981
Floods on the Limpopo River. Affected approximately 500 000 people.

1991 - 1992
Drought which affected several southern African countries. It is estimated that 1.32 million people were severely affected.

1995 – 1996
Drought which affected several southern African countries. The region experienced major crop failure and outbreaks of cholera in several parts.

1999
Flooding across the region caused by Cyclone Eline at the end of February 1999. More than 500 000 people were displaced and affected by the flooding.

1999 - 2000
Flooding across the region caused by heavy rains from December 1999 to January 2000.

2005
Drought across the region caused by prolonged dry spell from January to March 2005. Very high temperatures exacerbated the effects of prolonged drought conditions.

2014
Flooding across the region caused by heavy and extended rainfall during March 2014. Approximtely 32 people died and 3 525 people were displaced. There was also large-scale damage to infrastructure.

2015 – 2016
Drought across the region caused by the strong El Niño, the driest conditions in 35 years.

Figure 8: Summary of past extreme weather events (Lindevall, 2020)

The Limpopo River Basin is also affected by tropical cyclones which develop in the Southwest Indian Ocean Basin and strike the Mozambican coastline. Figure 9 presents the frequency of tropical cyclones over a period of 75 years from 1925 to 2000, as well as the path of more recent cyclones. The central region in which the Turfvlakte Project is located only experiences 1 to 3 cyclones over a 75-year period, whereas the Mozambican coastline experiences tropical cyclones far more frequently.

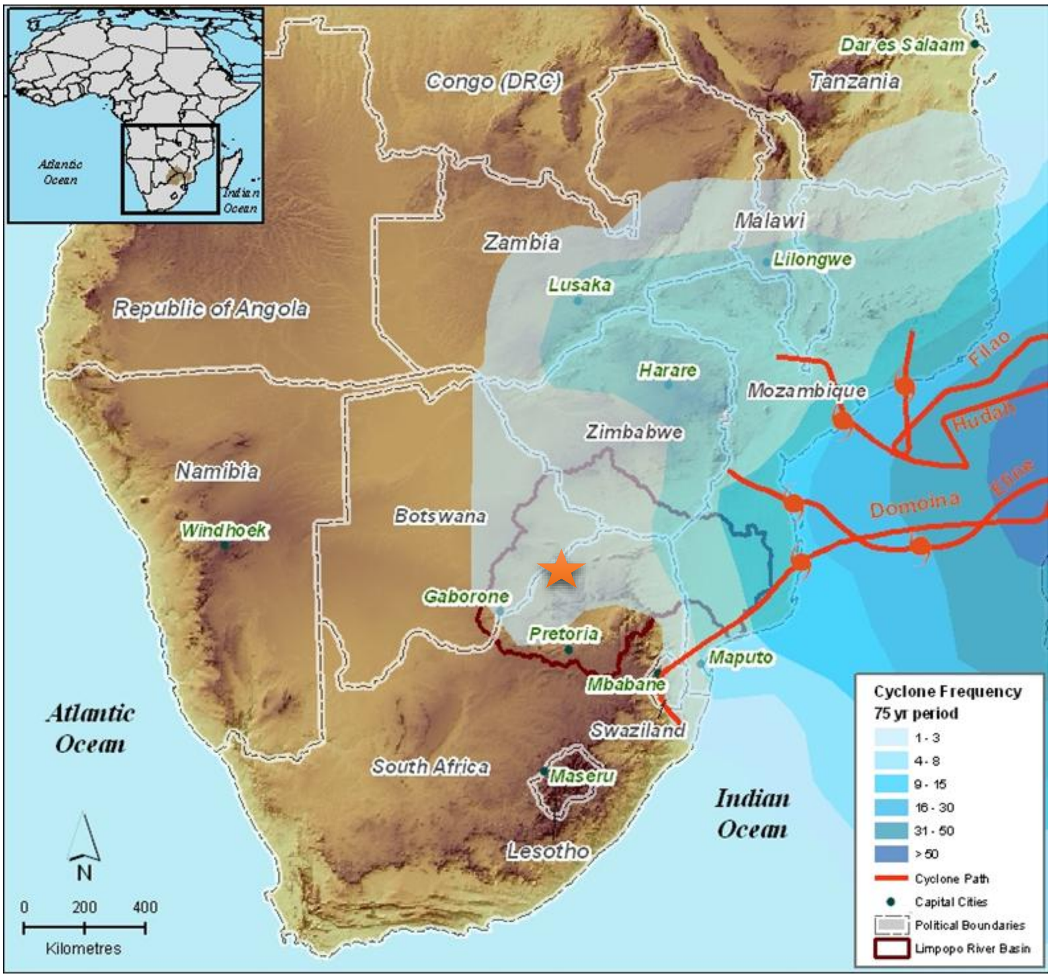


Figure 9: Frequency of tropical cyclones in Southern Africa (Hatfield Consultants and AHT Group AG, 2020)

5.0 EXPOSURE AND VULNERABILITY

The impact of climate change is not only dependent the climate-related hazards, but also on the exposure (the people and assets at risk) and vulnerability (susceptibility to harm) of the people and ecosystems that will be affected (IPCC, 2014).

Vulnerability is defined by the IPCC (2014) as *"the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."*

Exposure and vulnerability are influenced by a wide range of social, economic, and cultural factors and processes. This includes for example wealth, demographics, migration, access to information and technology, employment patterns, societal values, governance structures, and the quality of adaptive responses. People who are marginalised (e.g. economically, politically, or culturally) are especially vulnerable to the impacts of climate change and some mitigation and adaptation measures. It has been found that climate-related hazards often exacerbate existing stressors. For example, climate-related hazards affect the poor directly through impacts on their livelihoods, reductions in crop yields or destruction of their homes, and indirectly through food prices and food security.

Unfortunately, many of the predicted changes in climate and the associated impacts will continue for centuries, even if anthropocentric GHGs are stopped today. Furthermore, the risks of abrupt or irreversible changes in climate increases as the magnitude of global warming increases.

5.1 Lephalale

Figure 10 presents a summary of the sectors in Lephalale that may be exposed and vulnerable to future changes in climate. This is largely an adaptation of the sectors identified in the Limpopo Climate Change Strategy (2016-2020) as being especially vulnerable and screened for relevance to Lephalale. The sections to follow provide a more detailed description of each of these sectors.

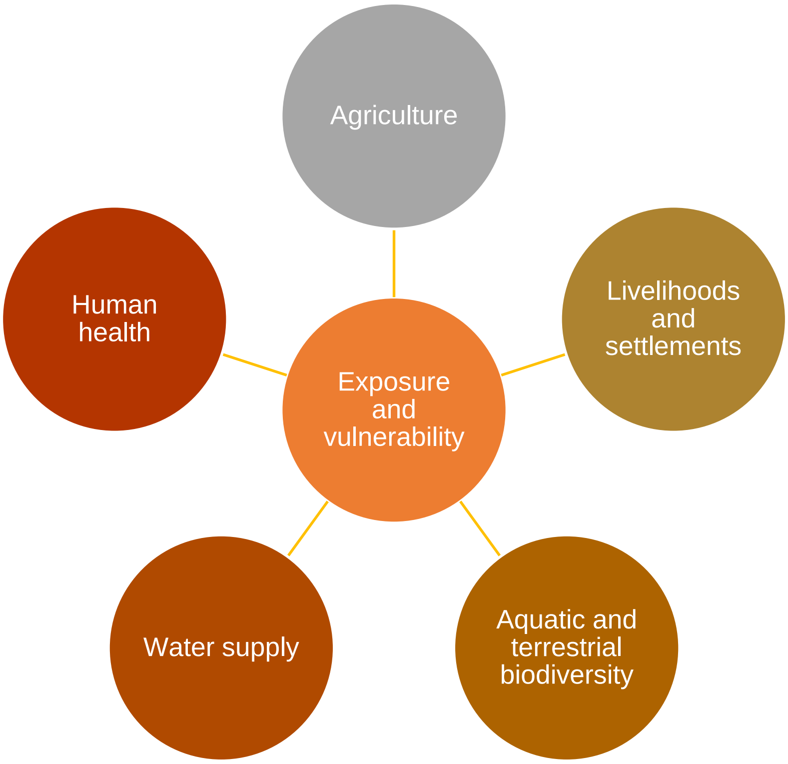


Figure 10: Sectors in Lephalale that may be exposed and vulnerable to changes in climate (adapted from DEDET, 2016)

5.1.1 Agriculture

Agriculture is an important sector in Lephalale, contributing significantly to the region's gross value added (approximately R160 million in 2014), as well as employment (approximately 4 800 people in 2014) (Urban-Econ, 2014).

The majority of the region is classified as non arable in terms of land capability (Class V and VI), with pockets of marginal potential arable land (Class IV) in the mountainous areas to the south of the town (Urban-Econ, 2014). These mountainous areas are interspersed with land that is only suitable for wildlife (Class VIII). The non-arable land is generally suitable for wildlife, forestry (subject to water availability), and moderate grazing. The marginal potential arable land is generally suitable for wildlife, forestry (subject to water availability), and intensive grazing. There are small areas of irrigated land along the Makolo and Lephalale Rivers.

The main cash crops which are grown in the region are maize, wheat, sunflower, groundnut, potatoes, onions, pumpkins, and oranges (Urban-Econ, 2014). The main livestock that are farmed in the region are cattle, sheep, game, and chickens.

Crop production in the region is only possible with some form of irrigation, which makes the sector vulnerable to changes in water availability in the future. The water scarcity in the region is an existing stressor which is likely to be exacerbated by future climate change.

5.1.2 Livelihoods and Settlements

In 2016, the population of the Lephalale Municipality was 140 240 with approximately 43 002 households (Lephalale Municipality, 2020). The population growth rate from 2011 to 2016 was approximately 3% per annum.

Approximately 29.2% of the population is under the age of 15, while only 3.5% of the population is over the age of 65. The dependency ratio or the percentage of the population that are not economically active is approximately 33.2%. The unemployment rate in 2016 was 22.2%, with a youth unemployment rate of 27%.

The average household size in 3.2 persons, with approximately 16 444 female-headed households (39.1%). Most of the households live in formal dwellings (82.3%), with only a limited number of households that have a flush toilet connected to sewer (41.6%) and piped water inside the dwelling (41.3%). Most households have electricity for lighting (89.4%). Of the 43 002 households, approximately 6 757 (22.6%) are classified as agricultural households.

Those households with a high dependency ratio, limited or no sources of income, dependent on agriculture, have a large household size, that are female headed, and without proper sanitation or access to potable water, are vulnerable to changes in climate. This is not only because these households are generally more exposed and sensitive to the impacts of climate change, but also because they have less capacity to adapt to the changes.

5.1.3 Aquatic and Terrestrial Biodiversity

Lephalale is located within the Savanna biome. There are three main vegetation types which occur in the region, namely Limpopo Sweet Bushveld, Roodeberg Bushveld, and Waterberg Mountain Bushveld. Neither of these vegetation types are classified as a Critically Endangered or Endangered ecosystems.

In comparison to other biomes, such as Grassland, the Savanna biome is relatively resilient to climate variability. As such it is not deemed to be especially vulnerable to future changes in climate. It is however unclear to what extent changes in temperature and rainfall, bush encroachment (elevated carbon dioxide (CO_2) levels), droughts, and wildfire will impact on vegetation structure and species composition.

There are two main rivers which flow through the region, namely the Mokolo and Lephalale Rivers. The Sandloop and Tambotie Rivers feed into the Makolo River just north of Lephalale. The overall ecological status of the Mokolo and Lephalale Rivers is characterised as 'Fair', while ecological importance and sensitivity of these rivers is characterised as 'Moderate' (Environomics *et al*., 2010). There are also several small, natural wetlands scattered throughout the region. Most of these wetlands are classified as AB: Largely Natural. There are no rivers or wetlands identified as National Freshwater Priority Areas in the region.

Aquatic ecosystems are especially vulnerable to changes in climate, particularly when they are in poor condition with limited functionality. Increased abstraction from rivers and dams can further increase the vulnerability of aquatic ecosystems to changes in climate.

5.1.4 Water Supply

There are two river catchments which fall within the Lephalale region, namely the Mokolo and Lephalale Rivers.

The Mokolo River Catchment drains 8 450 km^2 with an estimated mean annual runoff of 272 million cubic metres per annum (m^3/a) of which 98 million m^3/a can be utilised economically (Environomics *et al*., 2010). The Mokolo Dam is located halfway down the catchment. The dam was constructed in the late 1970s, primarily to supply water to the Matimba Power Station, but also to the town of Lephalale. Today, the dam also supplies downstream farmers with water for irrigation, as well as the Grootegeluk Coal Mine. The dam's water is currently fully allocated as follows:

- Matimba Power Station: 7.3 million m^3/a
- Grootegeluk Coal Mine: 9.9 million m^3/a
- Town of Lephalale: 1 million m^3/a
- Irrigation (downstream of dam): 10.4 million m^3/a

The Lephalale River Catchment drains 4866 km^2 with an estimated mean annual runoff of 135 million cubic metres per annum (Environomics *et al*., 2010). There is no major dam in this catchment area and irrigation is limited.

Lephalale has limited useable groundwater resources. The estimated borehole yields range from 0.1 – 2 ℓ per second, which is below the threshold of 2 – 5 ℓ per second to be considered a viable water source (Environomics *et al*., 2010).

Lephalale is considered to already be water scarce, and therefore especially vulnerable to changes in future climate. Furthermore, with increasing development in the region, the demand for water will increase pressure on existing finite water resources.

5.1.5 Human Health

Following HIV/AIDS (24.4%), hypertensive heart disease (6%), diarrhoea (5.8%), lower respiratory infection (5.8%), stroke (5.3%), and ischemic heart disease (4.4%) are the leading causes of death in the Limpopo Province (Bradshaw *et al*., 2000). Together, these diseases accounted for 33.3% of deaths in the province in 2000.

Assuming that the leading causes on mortality in Lephalale are similar to those of the province, the people of Lephalale are likely to be vulnerable to the impacts of rising temperatures and increased number of heat days as these are known to exacerbate heat stress, and increase the vulnerability of people with underlying conditions, such hypertensive heart disease, lower respiratory infection, stroke, and ischemic heart disease. Increased flooding due to extreme rainfall events are also known to exacerbate water-borne diseases, such as diarrhoea and cholera.

In South Africa, malaria transmission occurs in the low altitude areas (below 1 000 metres above mean sea level) in the provinces of Limpopo, Mpumalanga, and KwaZulu-Natal (NDOH, 2019). Malaria transmission generally occurs in the wet season between September and May. In Limpopo, the Vhembe and Mopani districts experience very high transmission, while the Waterberg, Sekhukhune and Capricorn districts experience very low local transmission. However, at the local level, Lephalale is characterised as a medium risk area as the municipality incidence rate is 5.56 per 1 000 population at risk in 2018. This is the third highest municipality incident rate in South Africa after Musina and Greater Letaba. While South Africa has made progress in eliminating Malaria in some parts of the country through indoor residual spraying, there are other parts where elimination has been less successful.

In the future, variations in climatic conditions, such as temperature, rainfall patterns, and humidity, can potentially increase malaria transmission, thereby increasing the vulnerability of people living and working in Lephalale.

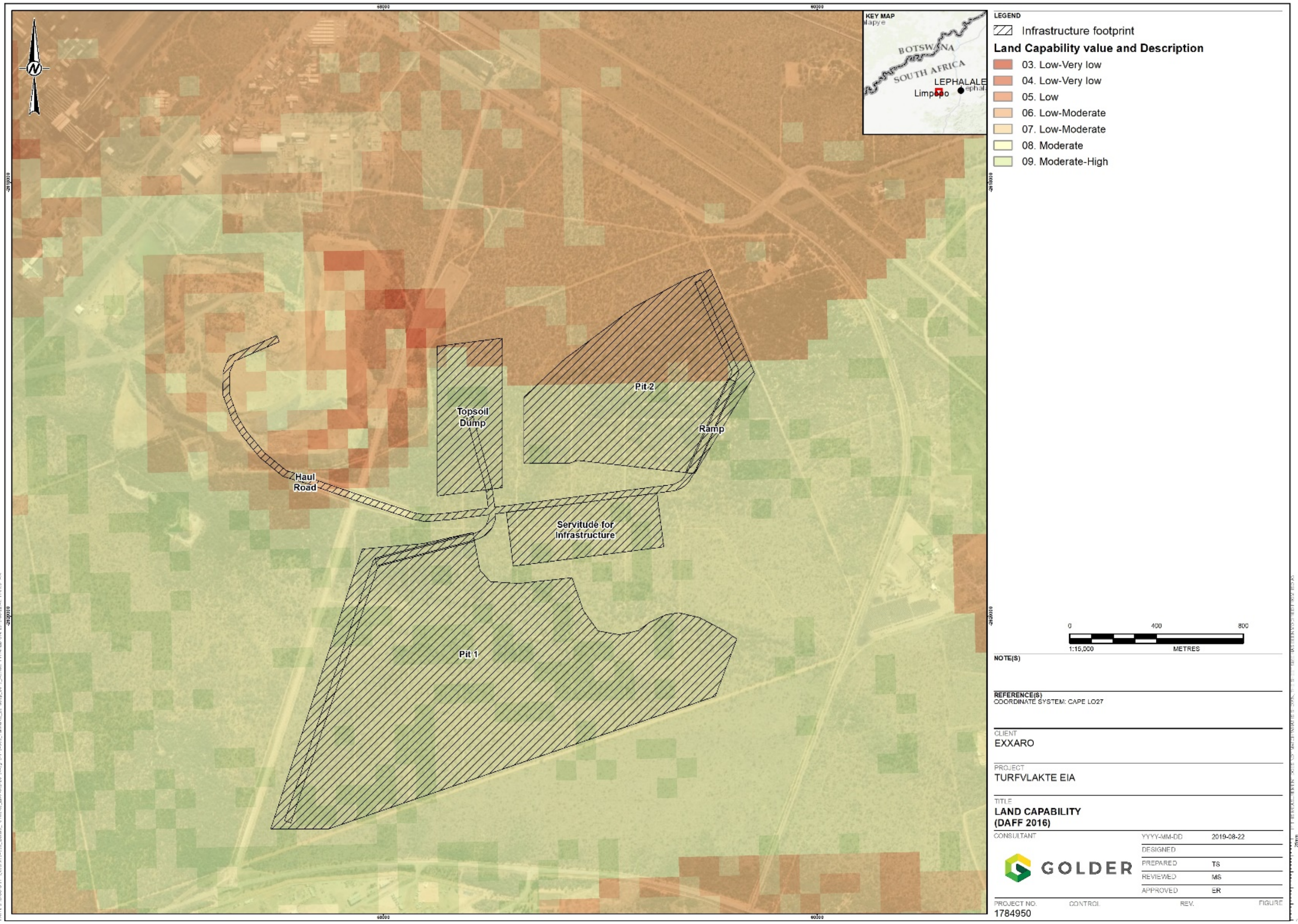
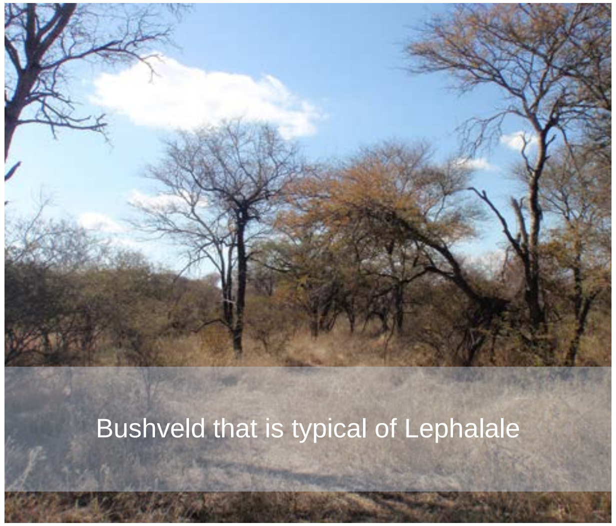


Figure 11: Land capability of areas surrounding the Project site

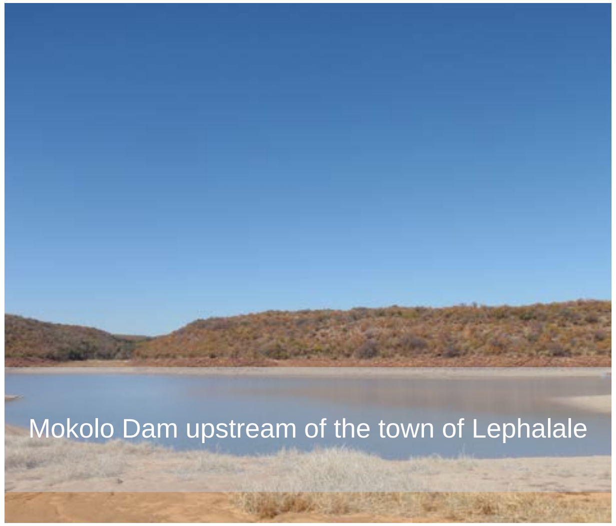
In recent years, there has been a transition from cattle farming to game farming

Informal settlements, such as this one in Marapong, are especially vulnerable to climate change impacts



Bushveld that is typical of Lephalale

Mokolo River downstream of the town of Lephalale



Mokolo Dam upstream of the town of Lephalale

Malaria is primarily transmitted by bite of the Anopheles mosquito

5.2 Turfvlakte Project

The following section identifies the main components of the Turfvlakte Project that could potentially be vulnerable to the projected impacts of climate change:

- Open pits
- Haul roads and ramps
- Topsoil dump
- Employees and contractors
- Beneficiation plants (at Grootegeluk Coal Mine)
- Grootegeluk Pit

6.0 CLIMATE CHANGE PROJECTIONS

There is significant evidence to suggest that human influence on the climate system is clear and that anthropocentric emissions of GHGs are the highest in history (IPCC, 2014).

Anthropogenic GHG emissions have increased since the pre-industrial era, driven largely by economic and population growth. This has resulted in atmospheric concentrations of CO_2, methane, and nitrous oxide, that are unprecedented in at least the last 800 000 years. This increase in atmospheric concentrations of GHGs has been identified with a high level of confidence as the main cause of observed global warming since the mid-20th century.

Several climate models have been developed in recent years in an attempt to simulate future climate change and the associated impacts. The predictions presented in this assessment are based on the 5th Phase of the Coupled Model Intercomparison Project ("CMIP5"), which comprises 35 global climate change models. CMIP5 is one of the most widely used models and is included in the Intergovernmental Panel on Climate Change ("IPPC")'s Fifth Assessment Report. The resolution of these simulations is 50 km.

This assessment also considers the ensemble of high-resolution climate model simulations performed at the Council for Scientific and Industrial Research ("CSIR"). These simulations consist of six (6) downscaled global climate change models (Engelbrecht, 2019). The downscaled simulations, which have a resolution of 8 km, have a number of advantages over the global 50 km resolution simulations. This includes more realistic modelling of convective rainfall and the influence of topographic features, such as the southern and eastern escarpments on temperatures, wind patterns, and rainfall.

Anthropogenic GHG emissions are mainly driven by factors, such as population size, economic activity, land use patterns, and technology. Climate change models use different scenarios, referred to as Representative Concentration Pathways ("RCPs"), for making predictions based on these factors. The following four RCPs are generally used:

- **RCP2.6:** Low emissions scenario, which aims to keep global warming below 2°C above pre-industrial temperatures
- **RCP4.5:** Low - medium emissions scenario
- **RCP6.0:** Medium – high emissions scenario
- **RCP8.5:** High emissions or business as usual scenario with no additional efforts to constrain emissions

Figure 12 (left) presents the trajectory of historical annual emissions (shown as a black line) and the projected annual emissions for each scenario or RCP. With RCP2.6, annual emissions are predicted to be 0 gigatonnes carbon dioxide equivalent (“$GtCO_2e$”) by 2100, with cumulative anthropogenic CO_2 emissions of 430 to 480 parts per million. At these concentrations, the temperature rise relative to pre-industrial levels is predicted to be 1.5 to 2°C (Figure 12 - right). With RCP8.5, annual emissions are predicted to be greater than 100 $GtCO_2e$ by 2100, with cumulative anthropocentric CO_2 emissions of more than 1 000 parts per million. At these concentrations, the temperature rise relative to pre-industrial levels is predicted to be greater than 4°C.

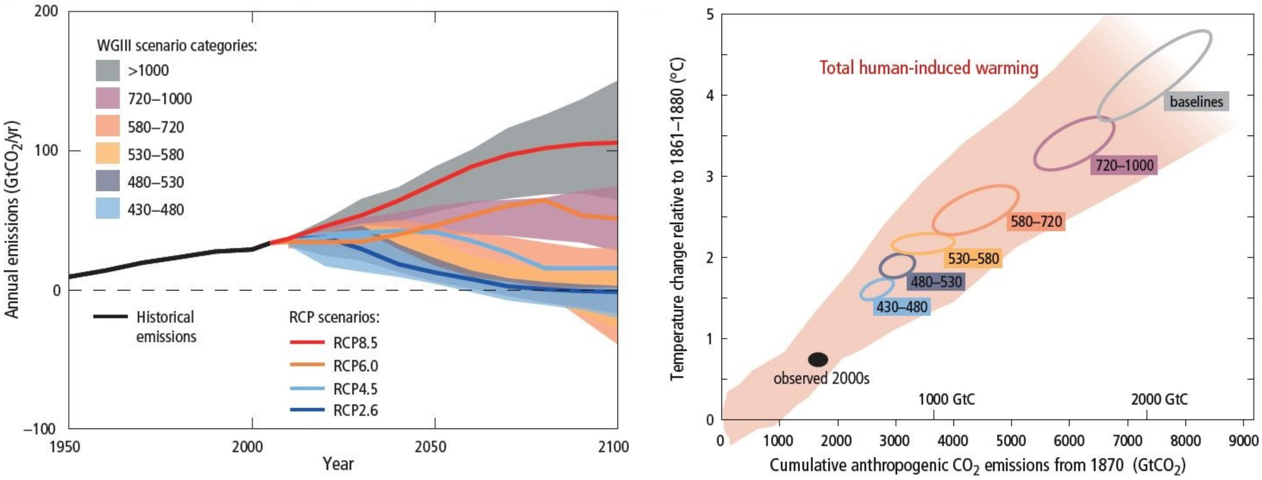


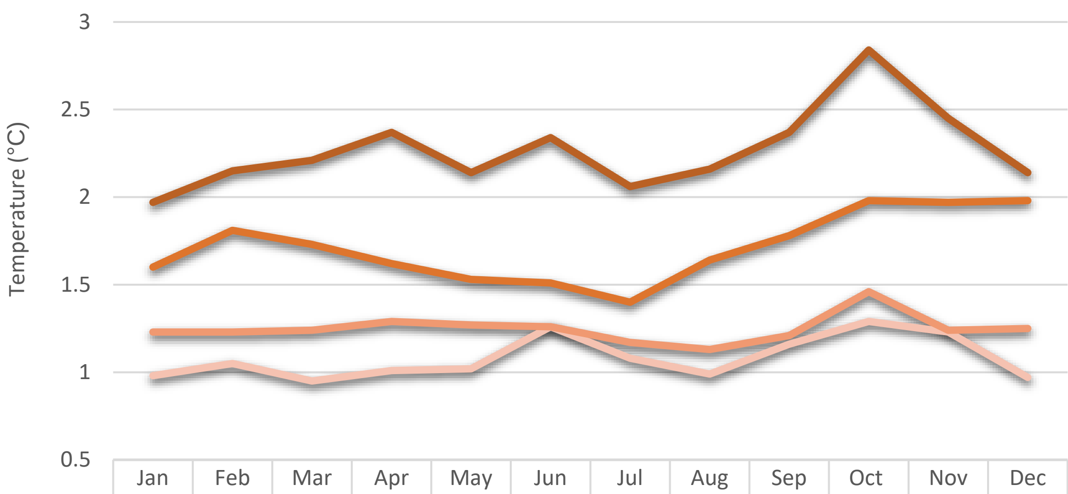
Figure 12: Annual anthropogenic GHG emissions (left) and warming versus cumulative anthropogenic GHG emissions (right) (IPCC, 2014)

The following section presents an overview of climate change projections for Lephalale in the short term (2020 to 2039) and medium-term (2040 to 2059) under two GHG mitigation scenarios (RCP 4.5 low-medium emissions and RCP8.5 high emissions). This includes average monthly temperature, number of hot days (>35°C), average monthly rainfall, and number of extreme rainfall days (>50 mm).

6.1 Temperature

6.1.1 Monthly Average Temperatures

In the short term, monthly average temperatures are projected to increase by 1.08°C (0.97°C to 1.29°C) in the low-medium emissions scenario and 1.25°C (1.21°C to 1.46°C) in the high emissions scenario (Figure 13). In the medium term, monthly average temperatures are projected to increase by 1.71°C (1.4°C to 1.98°C) in the low-medium emissions scenario and 2.27°C (1.97°C to 2.84°C) in the high emissions scenario.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RCP4.5 (2020-2039)	0.98	1.05	0.95	1.01	1.02	1.26	1.08	0.99	1.16	1.29	1.23	0.97
RCP8.5 (2020-2039)	1.23	1.23	1.24	1.29	1.27	1.26	1.17	1.13	1.21	1.46	1.24	1.25
RCP4.5 (2040-2059)	1.6	1.81	1.73	1.62	1.53	1.51	1.4	1.64	1.78	1.98	1.97	1.98
RCP8.5 (2040-2059)	1.97	2.15	2.21	2.37	2.14	2.34	2.06	2.16	2.37	2.84	2.45	2.14

Figure 13: Projected change in monthly average temperatures in Lephalale (World Bank, 2020)

According to CSIR (2019), annual average temperatures are projected to increase by 2.6 °C in the low-medium emissions scenario and 3.1°C in the high emissions scenario by 2050.

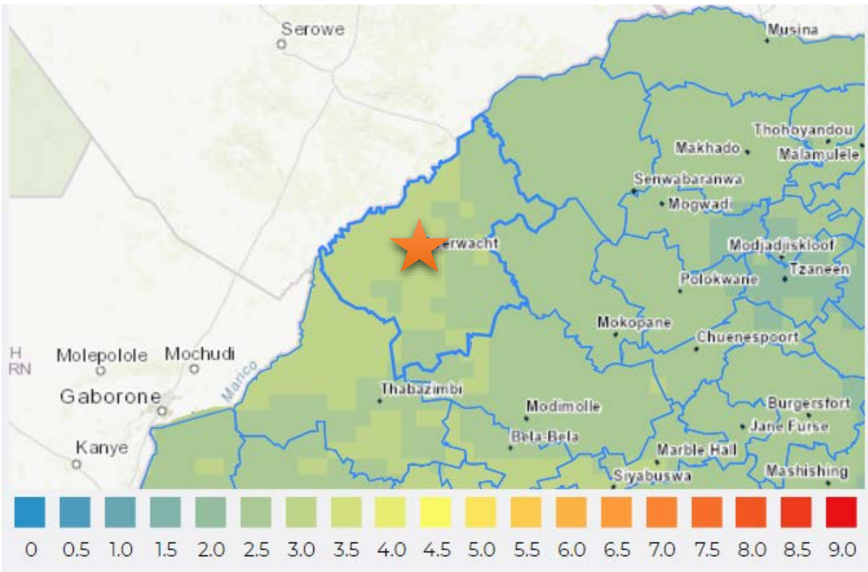
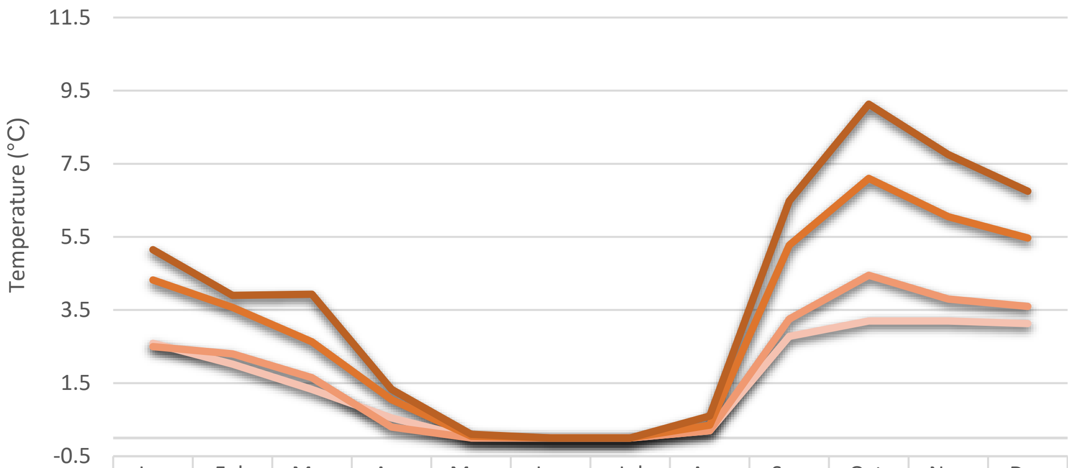


Figure 14: Changes in annual average temperatures by 2050 (CSIR, 2019)

6.1.2 Hot Days (>35°C)

In the short term, the number of hot days is projected to increase by 19 days (1.3 to 3.2 days per month) in the low-medium emissions scenario and 22 days (1.65 to 4.45 days per month) in the high emissions scenario, particularly in the summer months (September to March) (Figure 15). In the medium term, the number of hot days are projected to increase by 36 days (1.05 to 7.1 days per month) in the low-medium emissions scenario and 45 days (1.33 to 9.13 days per month) in the high emissions scenario.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RCP4.5 (2020-2039)	2.59	2.02	1.33	0.55	0	0	0	0.2	2.78	3.2	3.2	3.13
RCP8.5 (2020-2039)	2.5	2.3	1.65	0.3	0	0	0	0.2	3.25	4.45	3.8	3.6
RCP4.5 (2040-2059)	4.32	3.57	2.63	1.05	0.05	0	0	0.35	5.27	7.1	6.05	5.47
RCP8.5 (2040-2059)	5.15	3.9	3.93	1.33	0.1	0	0	0.6	6.48	9.13	7.75	6.75

Figure 15: Projected change in number of hot days in Lephalale (World Bank, 2020)

According to the CSIR (2019), the number of hot days are projected to increase by on average 59.2 days in the low-medium emissions scenario by 2050.

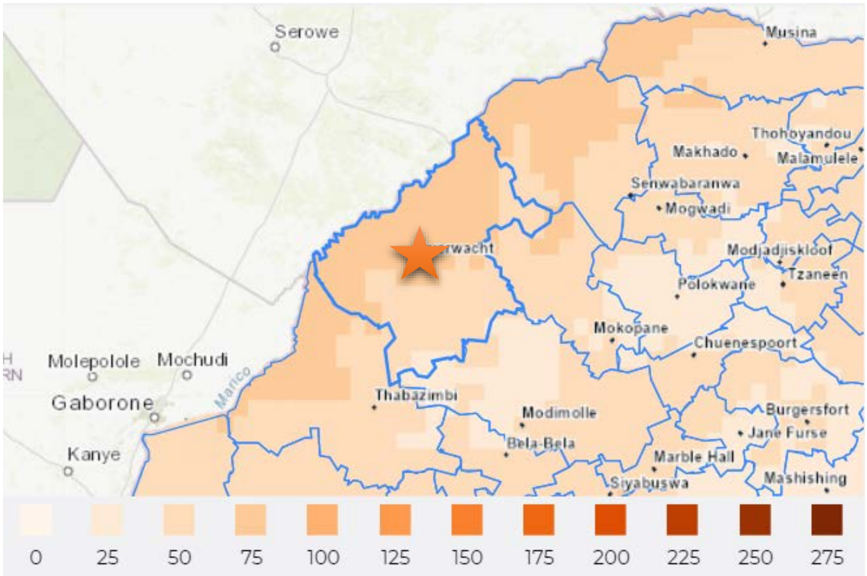


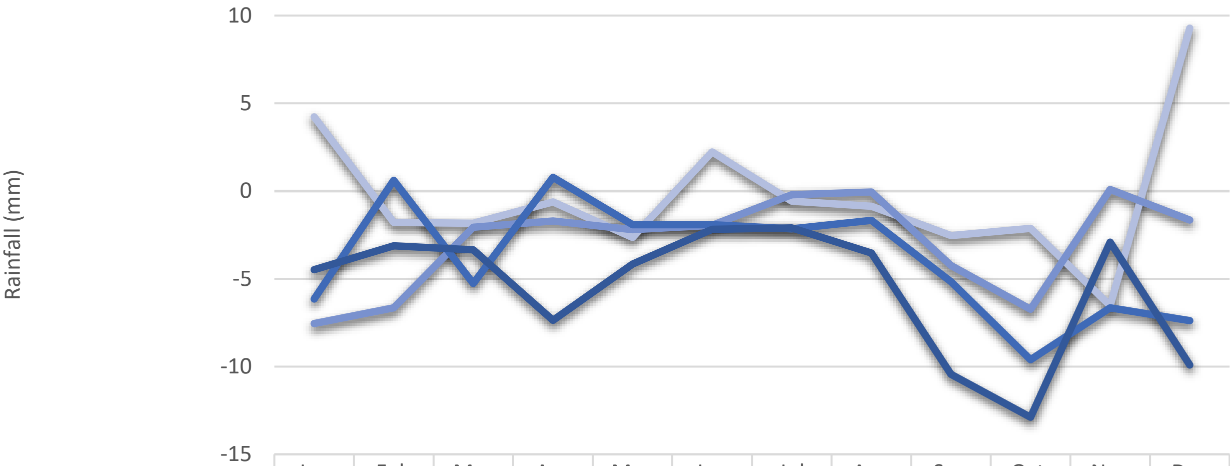
Figure 16: Changes in number of hot days by 2050 (CSIR, 2019)

6.2 Rainfall

6.2.1 Monthly Average Rainfall

In the short term, annual average rainfall is projected to decrease by 3.8 mm in the low-medium emissions scenario and 35 mm in the high emissions scenario (World Bank, 2020). Changes in monthly average rainfall in the low-medium emissions scenario range between a 6.5 mm decrease in November and 9.3 mm increase in December (Figure 17). In the high emissions scenario, changes in monthly average rainfall range between a 7.6 mm decrease in January and 0.9 mm increase in November.

In the medium term, annual average rainfall is projected to decrease by 46.5 mm in the low-medium emissions scenario and 66.4 mm in the high emissions scenario (World Bank, 2020). Changes in monthly average rainfall in the low-medium emissions scenario range between a 9.6 mm decrease in October and 0.78 mm increase in April. In the high emissions scenario, changes in monthly average rainfall range between a 2.1 mm decrease in July and 12.9 mm decrease in October.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RCP4.5 (2020-2039)	4.23	-1.79	-1.83	-0.62	-2.65	2.23	-0.57	-0.87	-2.54	-2.13	-6.53	9.28
RCP8.5 (2020-2039)	-7.55	-6.65	-2.06	-1.71	-2.2	-1.95	-0.21	-0.05	-4.24	-6.74	0.09	-1.65
RCP4.5 (2040-2059)	-6.15	0.61	-5.27	0.78	-1.92	-1.92	-2.15	-1.67	-5.17	-9.61	-6.65	-7.38
RCP8.5 (2040-2059)	-4.48	-3.12	-3.35	-7.37	-4.16	-2.18	-2.1	-3.53	-10.44	-12.89	-2.91	-9.91

Figure 17: Projected change in monthly average rainfall in Lephalale (World Bank, 2020)

According to the CSIR (2019), annual average rainfall is projected to decrease by 74.1 mm in the low-medium emissions scenario and 42.9 mm in the high emissions scenario by 2050.

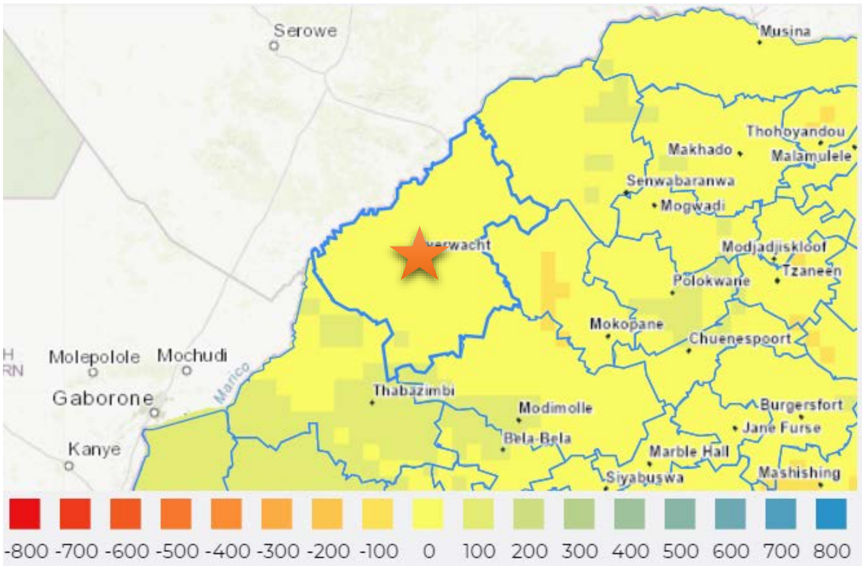
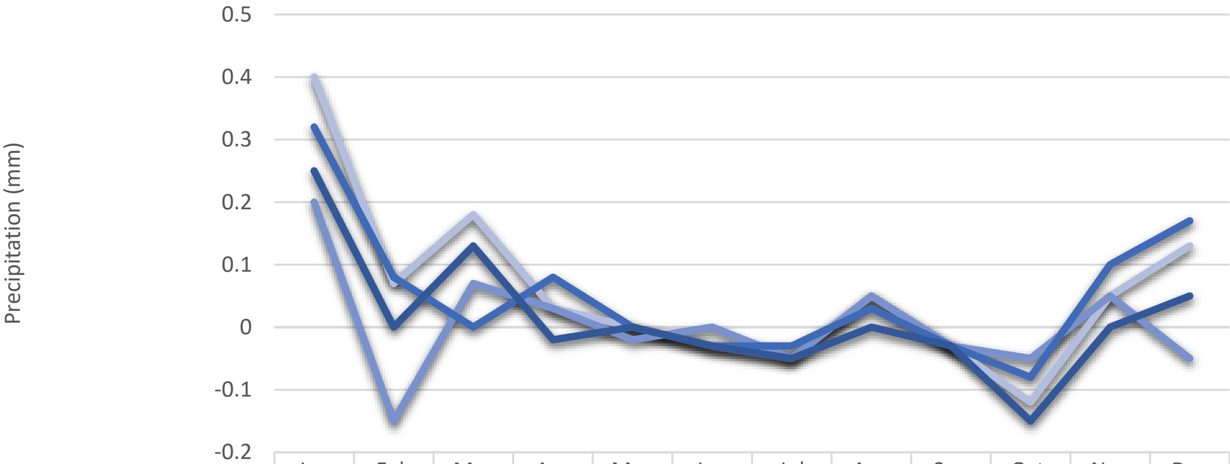


Figure 18: Changes in annual average rainfall by 2050 (CSIR, 2019)

6.2.2 Extreme Rainfall Days

In the short term, the number of extreme rainfall days are projected to increase by 0.68 days (-0.03 days to 0.18 days per month) in the low-medium emissions scenario and 0.05 days (-0.05 days to 0.2 days per month) in the high emissions scenario (World Bank, 2020). In the medium term, the number of extreme rainfall days are projected to increase by 0.61 days (-0.08 days to 0.32 days per month) in the low-medium emissions scenario and 0.15 days (-0.02 days to 0.25 days per month) in the high emissions scenario (Figure 19).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RCP4.5 (2020-2039)	0.4	0.07	0.18	0.03	0	-0.03	-0.05	0.05	-0.03	-0.12	0.05	0.13
RCP8.5 (2020-2039)	0.2	-0.15	0.07	0.03	-0.02	0	-0.05	0.05	-0.03	-0.05	0.05	-0.05
RCP4.5 (2040-2059)	0.32	0.08	0	0.08	0	-0.03	-0.03	0.03	-0.03	-0.08	0.1	0.17
RCP8.5 (2040-2059)	0.25	0	0.13	-0.02	0	-0.03	-0.05	0	-0.03	-0.15	0	0.05

Figure 19: Projected change in number of extreme rainfall days in Lephalale (World Bank, 2020)

According to the CSIR (2019), the number of extreme rainfall days are projected to decrease by 1.6 days in the low-medium emissions scenario and 1.1 days in the high emissions scenario by 2050.

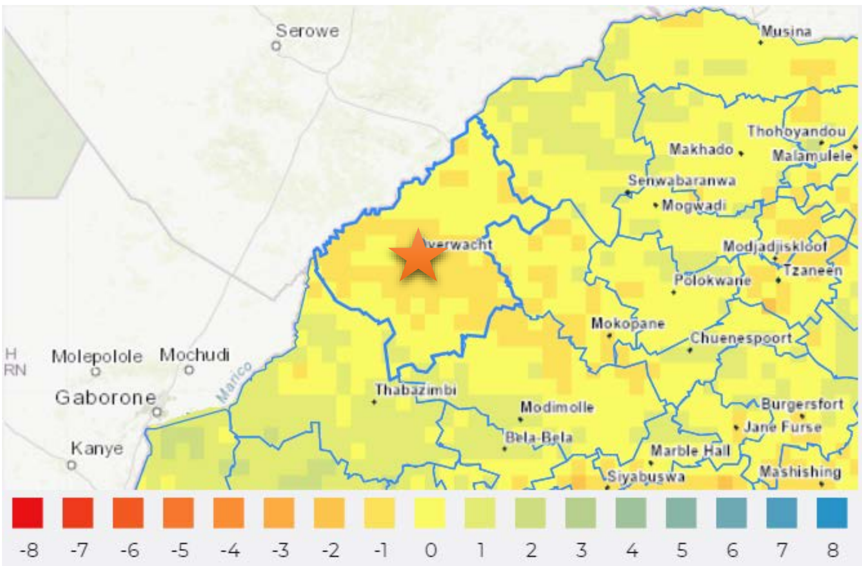


Figure 20: Changes in number of extreme rainfall days by 2050 (CSIR, 2019)

7.0 IMPACT ASSESSMENT

In recent decades, changes in climate have caused impacts on people and ecosystems around the world (IPCC, 2014). These impacts indicate the sensitivity of people and ecosystems to a changing climate. Changes in extreme weather and climate events have also been observed since the 1950s. This includes for example, an increase in warm temperature extremes, extreme high sea levels, and heavy rainfall events. Continued emissions of GHGs will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive, and irreversible impacts for people and ecosystems.

This section presents a qualitative assessment of the potential impacts of climate change on the vulnerable sectors in Lephalale, as detailed above in Section 5.1, as well as the vulnerable components of the Turfvlakte Project, as listed above in 5.2.

7.1 Approach to Impact Assessment

The impact assessment was undertaken using a matrix selection process, the most used methodology, for determining the significance of potential environmental impacts/risks. This methodology incorporates two aspects for assessing the potential significance of impacts, namely severity and probability of occurrence, which are further sub-divided as follows (Table 2).

Table 2: Impact assessment factors

Severity			Probability
Magnitude of impact	Duration of impact	Scale/extent of impact	Probability of occurrence

To assess these factors for each impact, the following four ranking scales are used (Table 3):

Table 3: Impact assessment scoring methodology

Value	Description
Magnitude	
10	Very high/unknown (of the highest order possible within the bounds of impacts that could occur. In the case of adverse impacts, there is no possible mitigation that could offset the impact, or mitigation is difficult, expensive, time-consuming or some combination of these. Social, cultural, and economic activities of communities are disrupted to such an extent that these come to a halt).
8	High
6	Moderate (impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. In the case of adverse impacts, mitigation is both feasible and easily possible. Social, cultural, and economic activities of communities are changed, but can be continued (albeit in a different form). Modification of the project design or alternative action may be required).
4	Low (impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts, mitigation is either easily achieved or little will be required, or both. Social, cultural, and economic activities of communities can continue unchanged.)
2	Minor
Duration	
5	Permanent (Permanent or beyond closure)

Value	Description
4	Long term (more than 15 years)
3	Medium-term (5 to 15 years)
2	Short-term (1 to 5 years)
1	Immediate (less than 1 year)
Scale	
5	International
4	National
3	Regional
2	Local
1	Site only
0	None
Probability	
5	Definite/unknown (impact will definitely occur)
4	Highly probable (most likely, 60% to 90% chance)
3	Medium probability (40% to 60% chance)
2	Low probability (5% to 40% chance)
1	Improbable (less than 5% chance)
0	None

Significance Points = (Magnitude + Duration + Scale) x Probability.

Table 4: Significance of impact based on point allocation

Points	Significance	Description
SP>60	High environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 - 60	Moderate environmental significance	An impact or benefit which is sufficiently important to require management, and which could have an influence on the decision unless it is mitigated.
SP<30	Low environmental significance	Impacts with little real effect and which will not have an influence on or require modification of the project design.
+	Positive impact	An impact that is likely to result in positive consequences/effects.

For the methodology outlined above (Table 3), the following definitions were used:

- **Magnitude** is a measure of the degree of change in a measurement or analysis (e.g., the severity of an impact on human health, well-being, and the environment), and is classified as none/negligible, low, moderate, high, or very high/unknown
- **Scale/Geographic extent** refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international
- **Duration** refers to the length of time over which an environmental impact may occur i.e. immediate/transient, short-term, medium term, long-term, or permanent
- **Probability** of occurrence is a description of the probability of the impact occurring as improbable, low probability, medium probability, highly probable or definite.

7.2 Lephalale

Table 5 presents a summary of the potential impacts detailed in the sections to follow, while Table 6 presents a summary of the recommended adaptation measures.

7.2.1 Agriculture

The increasing average monthly temperatures (0.97°C to 1.46°C in the short-term and 1.4°C to 3.1°C in the medium-term) and number of hot days (19 to 22 days in the short-term and 36 to 59 days in the medium-term) can lead to increased evapotranspiration (which already exceeds rainfall), potentially reducing cropping area, yield (tonne/ha) and product quality. The rising temperatures can also lead to an exceedance of the temperature humidity index in livestock, causing reduced immunity, fertility, productivity, and even mortality of livestock.

The decreasing rainfall (3.8 mm to 34.9 mm in the short-term, and 42.9 mm to 72.1 mm in the medium-term) can also lead to reduced yield and product quality, as well as reduced fodder quantity and quality for livestock.

The increasing temperatures and number of hot days can also increase the demand for water for irrigation, increasing the strain on the existing finite water resources. Increased evapotranspiration can also lead to reduced storage capacity in dams and reservoirs.

Without mitigation, the significance of the impact is likely to be moderate. The magnitude of the impact is likely to be moderate (farming is able to continue, albeit with some losses), permanent in duration (climatic conditions are likely to persist beyond 2100), regional in extent, and a high probability of occurrence (60%-90% chance). With mitigation, the significance of the impact is likely to remain moderate. This is mostly because Exxaro has limited influence on agricultural activities outside of their mining rights area.

7.2.2 Livelihoods and Settlements

There are approximately 6 757 households (22.6% of total households) that are dependent on agriculture for their livelihoods. The increasing average monthly temperatures and number of hot days can lead to reduced crop yields and even crop losses. As many of these households practice dryland irrigation, decreasing rainfall can exacerbate the reduction in crop yields, thereby impacting on the food security of these households.

Without mitigation, the significance of this impact is likely to be high. The magnitude of the impact is likely to be high (potential for total crop losses with limited alternative livelihood options), permanent in duration (climatic conditions are likely to persist beyond 2100), regional in extent, and a high probability of occurrence (60% to 90% chance). With mitigation, the significance of the impact is likely to be moderate, as the probability of occurrence can be reduced from highly probable to medium probability.

The recommended adaptation measures are as follows:

- Implementing a community awareness program to educate communities about climate change, the predicted changes in temperature and rainfall, and best practice methods for reducing crop and livestock losses
- Develop and implement a community awareness program to educate the local community about water conservation and demand management
- Develop and implement a rainwater harvesting programme to provide dwellings without potable water inside with a concrete rainwater tank

7.2.3 Aquatic and Terrestrial Biodiversity

Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration, drought conditions, and the frequency and intensity of wildfires, which can impact negatively on the terrestrial ecosystems (i.e. bushveld) in Lephalale. These impacts may be exacerbated by increased CO_2 concentrations in the atmosphere, which is known to facilitate bush encroachment.

Without mitigation, the significance of the impact on terrestrial ecosystems is likely to be moderate. The magnitude of the impact is likely to be medium (savanna is relatively resilient), permanent in duration (climatic conditions are likely to persist beyond 2100), regional in extent, and a high probability of occurrence (60% to 90% chance). With mitigation, the significance of the impact is likely to remain moderate. This is mostly because Exxaro has limited influence on the terrestrial ecosystems outside of their mining rights area.

The recommended adaptation measures are as follows:

- Develop and implement an onsite rehabilitation programme to rehabilitate areas disturbed by construction and mining activities
- Develop and implement an alien invasive species control programme to manage the spread of alien invasive species onsite

Similarly, increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration, reduced runoff, and drought conditions, which can impact negatively on aquatic ecosystems (i.e. rivers, pans, and wetlands) in Lephalale. These impacts can be exacerbated by increased abstraction from rivers and dams.

Without mitigation, the significance of the impact on aquatic ecosystems is likely to be high. The magnitude of the impact is likely to be high (likely to cause severe impairment of aquatic ecosystems), permanent in duration (climatic conditions are likely to persist beyond 2100), regional in extent, and high probability of occurrence (60% to 90% chance). With mitigation, the significance of the impact is likely to remain high. This is mostly because the only influence that Exxaro has on the aquatic ecosystems outside of their mining rights area is the quantity of water consumed.

The recommended adaptation measures are as follows:

- Develop a water conservation/water demand management plan for the Turfvlakte Project and incorporate it into the existing water conservation/water demand management plan for Grootegeluk Coal Mine for implementation

7.2.4 Water Supply

Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration and the increase in frequency and severity of droughts. This can reduce water availability in a region which is already known to be water scarce.

Without mitigation, the significance of the impact on water availability is likely to be moderate. The magnitude of the impact is likely to be medium (existing water uses can continue albeit with some modifications), permanent in duration (climatic conditions are likely to persist beyond 2100), regional in extent, and high probability of occurrence (60% to 90% chance). With mitigation, the significance of the impact is likely to remain moderate. This is mostly because the only influence that Exxaro has on the water supply in Lephalale is the quantity of water consumed.

The recommended adaptation measures are as follows:

- Develop a water conservation/water demand management plan for the Turfvlakte Project and incorporate it into the existing water conservation/water demand management plan for Grootegeluk Coal Mine for implementation

7.2.5 Human Health

Increases in average temperatures and number of hot days can increase the risk of people living in Lephalale, especially those with underlying conditions, suffering from heat stroke and dehydration, which can adversely affect their health and well-being.

Without mitigation, the impact on people's health and well-being due to heat stroke and dehydration is likely to be moderate. The magnitude of the impact is likely to be high (known to be life threatening), permanent in duration (climatic conditions are likely to persist beyond 2100), regional in extent, and low probability of occurrence (5% to 40% chance). With mitigation, the significance of the impact is likely to remain low. This is mostly because Exxaro has limited influence on the general population in Lephalale.

Variations in climatic conditions, such as temperature, rainfall patterns, and humidity, can increase malaria transmission, which can adversely affect the health and well-being of people living in Lephalale.

Without mitigation, the impact on people's health and well-being due to malaria is likely to be moderate. The magnitude of the impact is likely to be high (known to be life threatening), permanent in duration (climatic conditions are likely to persist beyond 2100), regional in extent, and low probability of occurrence (5% to 40% chance). With mitigation, the significance of the impact is likely to remain low. This is mostly because Exxaro has limited influence on the general population in Lephalale.

7.3 Turfvlakte Project

Table 5 presents a summary of the potential impacts detailed in the sections to follow, while Table 6 presents a summary of the recommended adaptation measures.

7.3.1 Construction Phase

Given that construction is due to start in 2022, it is expected that the climatic conditions at the time will be very similar to the baseline climatic conditions presented in Section 4.0. The potential impacts of climate change during the construction phase have therefore not been considered in this assessment.

7.3.2 Operational Phase

7.3.2.1 Open Pits

In general, it is projected that there will be a decrease in annual average rainfall in the short-term (2020 to 2039) of between 3.8 mm to 34.9 mm. A decrease in annual average rainfall will reduce direct rainfall onto the open pits, surface runoff, and groundwater infiltration, thereby reducing pit dewatering requirements.

The direction of this impact is likely to be positive due to the reduced pit dewatering requirements. The magnitude is likely to be moderate due to minor decreases in average annual rainfall (<1% to 7.5%). Furthermore, the contribution of direct rainfall to pit water is also negligible when compared to groundwater inflow. The duration will be medium (life of mine), extent limited to the site only, with a high probability of occurrence.

The recommended adaptation measures are as follows:

- Limit the area in the immediate vicinity of the open pits that will be graded to drain towards the open pits
- Construction of diversion channels and ditches to direct non-contact water away from the open pits
- Use of pit floor sumps to pump pit water to Grootegeluk Coal Mine where it will be used for dust suppression and process water

7.3.2.2 Haul Roads and Ramps

It is projected that there will be negligible increase in the number of extreme rainfall days in the short term (2020 to 2039) of between 0.05 days and 0.68 days. An increase in the number of extreme rainfall days can make access roads temporarily impassable, impacting negatively on the transport of overburden, interburden, and coal from the open pits to Grootegeluk Coal Mine.

Without mitigation, the significance of the impact is likely to be low because of the low magnitude of the impact (temporary delay), short duration (days), and the limited extent (site only). The probability of occurrence is likely to be improbable. The significance of the impact would remain low with mitigation.

The recommended adaptation measures are as follows:

- Ensure that haul roads and ramps are maintained in good condition by attending to potholes, corrugations, and stormwater damage as soon as these develop

7.3.2.3 Topsoil Dump

As mentioned previously, it is projected that there will be negligible increase in the number of extreme rainfall days in the short term (2020 to 2039) of between 0.05 days and 0.68 days. An increase in the number of extreme rainfall days can lead to increased erosion of the exposed topsoil dump, and sedimentation of the stormwater system and/or receiving environment.

Without mitigation, the significance of the impact is likely to be low because of the low magnitude of the impact, short term duration, and local extent (site and immediate surrounds). The probability of occurrence is likely to be improbable. The significance of the impact would remain low with mitigation.

The recommended adaptation measures are as follows:

- Construction of upslope diversion berms to divert stormwater runoff around the topsoil dump
- Construction of conduits to direct runoff from the topsoil dump to a stormwater outfall point

7.3.2.4 Employees and Contractors

It is projected that there will be an increase in monthly average temperatures in the short term (2020 to 2039) of between 1.08°C and 1.25°C. It is also projected that there will be an increase in the number of hot days of between 19 days and 22 days. An increase in average monthly temperatures and number of hot days can increase the risk of employees and contractors suffering from heat stroke and dehydration, which can adversely affect their health and well-being.

Without mitigation, the significance of this impact is likely to be moderate because of the high magnitude of the impact (can be life threatening), medium-term duration (life of mine), extent that is limited to the site only, and medium probability of occurring. With mitigation, the significance of this impact is likely to be low due to a decrease in the probability of occurring from medium to low.

The recommended adaptation measures are as follows:

- Develop and implement an employee health awareness program to educate Exxaro's employees and contractors about the importance of drinking water and identifying the signs of early signs of heat stroke

Variations in climatic conditions, such as temperature, rainfall patterns, and humidity, can increase malaria transmission, which can adversely affect the health and well-being of employees and contractors.

Without mitigation, the significance of this impact is likely to be moderate because of the high magnitude of the impact (can be life threatening), medium-term duration (life of mine), extent that is limited to the site only, and medium probability of occurring. With mitigation, the significance of this impact is likely to be low due to a decrease in the probability of occurring from medium to low.

The recommended adaptation measures are as follows:

- Monitor malaria incident reports
- If local incidents are reported, implement fogging and spraying at the mine during the wet season (September to April)
- Develop and implement an employee health awareness program to educate Exxaro's employees and contractors about Malaria and preventative measures

7.3.2.5 Beneficiation Plants

It is projected that there will be a decrease in annual average rainfall in the short term of between 3.8 mm and 34.9 mm (<1% to 7.5% decrease). A decrease in average annual rainfall will reduce direct rainfall onto the open pits, surface runoff, and groundwater infiltration, thereby reducing the availability of pit water for the beneficiation plants at Grootegeluk Coal Mine.

Note that these beneficiation plants have been included in this assessment as the coal from the Turfvlakte Project will be transported to the said plants for further beneficiation. The plants are therefore deemed to be a critical component of the Turfvlakte Project's operations.

Without mitigation, the significance of the impact is likely to be moderate because of the low magnitude of the impact (pit water is only a supplementary water source), medium duration (life of mine), local extent, and high probability of occurring. With mitigation, the significance of the impact is likely to be low due to a decrease in the magnitude from low to minor.

The recommended adaptation measures are as follows:

- Develop a water conservation/water demand management plan for the Turfvlakte Project and incorporate it into the existing water conservation/water demand management plan for Grootegeluk Coal Mine for implementation

7.3.2.6 Grootegeluk Pit

In the short term, monthly average temperatures are projected to increase by between 0.97°C and 1.46°C, while the number of hot days is projected to increase by between 19 days and 22 days.

Marked increases in daily or seasonal temperatures will increase the rate of oxidation, thereby increasing exothermic reactions and the risk of spontaneous combustion of the coal discards in the backfill of the Grootegeluk Pit. The rate of exothermic reactions is directly related to the temperature, where each 10°C rise in temperature leads to an almost doubling of the oxidation process. Spontaneous combustion of the coal discards poses a risk to the safety of employees during the operational phase. The burning discards will also produce air pollutants which can negatively affect ambient air quality.

Note that the Grootegeluk Pit has been included in this assessment as the coal discard from the processing of ROM coal from the Turfvlakte Project will be backfilled in the said pit. The Grootegeluk Pit is therefore deemed to be a critical component of the Turfvlakte Project's operations.

Without mitigation, the significance of this impact is likely to be moderate. The magnitude of this impact is expected to be high (can be life threatening), with medium duration (life of mine), local extent, and high probability of occurrence. With mitigation, the significance of this impact is likely to low, due to a decrease in the probability of occurrence from medium to low.

The recommended adaptation measures are as follows:

- Where possible, cap each bench to minimise the exposed surface area for exothermic reactions and to prevent the ingress of oxygen and moisture
- Annual thermographic surveys of Dump 6 to identify 'hotspots' or potential spontaneous combustion areas.

7.3.3 Closure Phase

7.3.3.1 Rehabilitated Mining Areas

It is projected that there will be an increase in monthly average temperatures in the medium-term of between 1.4°C and 3.1°C, while the number of hot days are projected to increase by between 36 days and 59 days. It is also projected that there will be a decrease in annual average rainfall in the medium-term of between 46.5 mm and 72.1 mm (10% to 15.5% decrease).

A decrease in annual average rainfall, coupled with an increase in monthly average temperatures and evaporation rates, will reduce the water availability to the plants used in the rehabilitation of mining areas. This can impact negatively on the establishment of vegetation on these areas, and their stability in the long-term.

Without mitigation, the significance of the impact is likely to be moderate. The magnitude of the impact is likely to be moderate (erosion of poorly vegetated surfaces), with long-term duration (extend beyond life of mine), extent limited to the site only, and medium probability of occurrence. With mitigation, the significance of the impact is likely to be low as the probability of occurrence can potentially be reduced from medium to low.

The recommended adaptation measures are as follows:

- Post-closure monitoring of the re-vegetated areas on an annual basis. If required, apply new topsoil, fertilise, reseed/replant, and water areas where plants have been washed away or struggling to become established

Table 5: Summary of potential impacts during the operational and closure phases

Vulnerable sector/ component	Potential Impact	Impact Assessment Factors		Probability	Significance without mitigation	Impact Assessment Factors		Probability	Significance with mitigation
1.0 Lephalale									
Livelihoods and settlements	Increased temperatures and hot days, together with decreased rainfall, can lead to decreased crop areas, crop yield, and crop quality, as well as livestock infertility, productivity losses, and even mortality.	Magnitude:	Moderate	Highly probable	Moderate	Magnitude:	Moderate	Highly probable	Moderate
		Duration:	Permanent			Duration:	Permanent		
		Scale:	Regional			Scale:	Regional		
Livelihoods and settlements	Increased temperatures and hot days, together with decreased rainfall, can lead to decreased crop yields and even crop losses.	Magnitude:	High	Highly Probable	High	Magnitude:	High	Medium	Moderate
		Duration:	Permanent			Duration:	Permanent		
		Scale:	Regional			Scale:	Regional		
Aquatic and terrestrial biodiversity	Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration, drought conditions, and the frequency and intensity of wildfires, which can impact negatively on the terrestrial ecosystems.	Magnitude:	Moderate	Highly probable	Moderate	Magnitude:	Moderate	Medium	Moderate
		Duration:	Permanent			Duration:	Permanent		
		Scale:	Regional			Scale:	Regional		
	Increases in average temperatures and number of hot days,	Magnitude:	High	Highly Probable	High	Magnitude:	High	Highly Probable	High
		Duration:	Permanent			Duration:	Permanent		

Vulnerable sector/ component	Potential Impact	Impact Assessment Factors		Probability	Significance without mitigation	Impact Assessment Factors		Probability	Significance with mitigation
Aquatic and terrestrial biodiversity	coupled with decreasing average rainfall, can lead to increased evapotranspiration, reduced runoff, and drought conditions, which can impact negatively on aquatic ecosystems (i.e. rivers, pans, and wetlands) in Lephalale.	Scale:	Regional			Scale:	Regional		
Water supply	Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration and the increase in frequency and severity of droughts. This can reduce water availability in a region which is already known to be water scarce.	Magnitude:	Moderate	Highly probable	Moderate	Magnitude:	Moderate	Highly probable	Moderate
		Duration:	Permanent			Duration:	Permanent		
		Scale:	Regional			Scale:	Regional		
Human health	Increases in average annual temperatures and number of hot days (>35°C) can increase risk of people living in Lephalale, especially those with underlying conditions, suffering from heat stroke and dehydration, which can adversely affect their health and well-being	Magnitude:	High	Low	Moderate	Magnitude:	High	Low	Moderate
		Duration:	Permanent			Duration:	Permanent		
		Scale:	Regional			Scale:	Regional		

Vulnerable sector/ component	Potential Impact	Impact Assessment Factors		Probability	Significance without mitigation	Impact Assessment Factors		Probability	Significance with mitigation
Human health	Variations in climatic conditions, such as temperature, rainfall patterns, and humidity, can increase malaria transmission, which can adversely affect the health and well-being of people living in Lephalale.	Magnitude:	High	Low	Moderate	Magnitude:	High	Low	Moderate
		Duration:	Permanent			Duration:	Permanent		
		Scale:	Regional			Scale:	Regional		
2. Turfvlakte Project									
2.1 Operational Phase									
Open pits	A decrease in average annual rainfall will reduce direct rainfall onto the open pits, surface runoff, and groundwater infiltration, thereby reducing pit dewatering requirements.	Magnitude:	Moderate	Moderate	Positive	Magnitude:	Moderate	Moderate	Positive
		Duration:	Medium			Duration:	Medium		
		Scale:	Local			Scale:	Local		
Haul roads and ramps	An increase in the number of extreme rainfall days can make access roads temporarily impassable, impacting negatively on the transport of overburden, interburden, and coal from the pits to Grootegeluk Coal Mine.	Magnitude:	Low	Improbable	Low	Magnitude:	Low	Improbable	Low
		Duration:	Short			Duration:	Short		
		Scale:	Site only			Scale:	Site only		
Topsoil dump	An increase in the number of extreme	Magnitude:	Short	Improbable	Low	Magnitude:	Low	Improbable	Low
		Duration:	Site only			Duration:	Short		

Vulnerable sector/ component	Potential Impact	Impact Assessment Factors		Probability	Significance without mitigation	Impact Assessment Factors		Probability	Significance with mitigation
	rainfall days can lead to increased erosion of the exposed soil stockpiles, and sedimentation of the stormwater system or receiving environment.	Scale:	Short			Scale:	Site only		
Employees and contractors	An increase in average monthly temperatures and number of hot days can increase the risk of employees suffering from heat stroke and dehydration, which can adversely affect their health and well-being.	Magnitude:	High	High	Moderate	Magnitude:	High	Low	Low
		Duration:	Medium			Duration:	Medium		
		Scale:	Site			Scale:	Site		
Employees and contractors	Variations in climatic conditions, such as temperature, rainfall patterns, and humidity, can increase malaria transmission, which can adversely affect the health and well-being of employees and contractors.	Magnitude:	High	High	Moderate	Magnitude:	High	Low	Low
		Duration:	Medium			Duration:	Medium		
		Scale:	Site			Scale:	Site		
Beneficiation plants4	A decrease in average annual rainfall will reduce direct rainfall onto the open pits, surface runoff, and groundwater infiltration, thereby reducing the availability of pit water for the	Magnitude:	Low	Highly probable	Moderate	Magnitude:	Minor	Highly probable	Low
		Duration:	Medium			Duration:	Medium		
		Scale:	Local			Scale:	Local		

Vulnerable sector/ component	Potential Impact	Impact Assessment Factors		Probability	Significance without mitigation	Impact Assessment Factors		Probability	Significance with mitigation
	beneficiation plants at Grootegeluk Coal Mine.								
Grootegeluk Pit	Marked increases in daily or seasonal temperatures will increase the rate of oxidation, thereby increasing exothermic reactions and the risk of spontaneous combustion of the coal discards in the backfill of the Grootegeluk Pit.	Magnitude:	High	Medium	Moderate	Magnitude:	High	Low	Low
		Duration:	Medium			Duration:	Medium		
		Scale:	Local			Scale:	Local		
2.2 Closure Phase									
Rehabilitated mining areas	A decrease in average annual rainfall, coupled with an increase in average monthly temperatures and evaporation rates, will reduce the water availability to the plants used in rehabilitation of mining areas. This can impact negatively on the establishment of vegetation on these areas, and their stability in the long-term.	Magnitude:	Moderate	Medium	Moderate	Magnitude:	Moderate	Low	Low
		Duration:	Long			Duration:	Long		
		Scale:	Site			Scale:	Site		

8.0 ADAPTATION MEASURES

Limiting the impacts of climate change on people and ecosystems requires not only a substantial and sustained reduction in GHG emissions, but also adaptation (IPCC, 2014). Adaptation can reduce the risks of climate change impacts, but the effectiveness is dependent on magnitude and rate of climate change. The first step in adapting to future climate change is reducing vulnerability and exposure to future climate change.

Table 6 presents a summary of the recommendations for reducing the vulnerability and exposure of the Turfvlakte Project to the predicted changes in climate. Also presented are high-level recommendations for reducing the vulnerability and exposure of the people and ecosystems in Lephalale to the predicted changes in climate. This is however limited to recommendations that Exxaro can successfully implement through their existing initiatives in the area.

Table 6: Summary of the recommended adaptation measures

Vulnerable sector/ component	Potential impact	No.	Detailed actions	Timeframes	Responsibility
1. Lephalale					
1.1 Livelihoods and settlements	Increased temperatures and hot days, together with decreased rainfall, can lead to decreased crop yields and even crop losses.	1.1.1	Implementing a community awareness program to educate communities about climate change, the predicted changes in temperature and rainfall, and best practice methods for reducing crop and livestock losses.	Duration of operational phase.	Community
		1.1.2	Develop and implement a community awareness program to educate the local community about water conservation and demand management.	Duration of operational phase.	Community
		1.1.3	Develop and implement a rainwater harvesting programme to provide dwellings without potable water inside with a concrete rainwater tank.	At the start of the operational phase	Community
1.2 Aquatic and terrestrial ecosystems	Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration, drought conditions, and the frequency and intensity of wildfires, which can impact negatively on the terrestrial ecosystems.	1.2.1	Develop and implement an onsite rehabilitation programme to rehabilitate areas disturbed by construction and mining activities.	At the start of construction and duration of operational and closure phases	Safety, Health, Environment and Quality (“SHEQ”)
		1.2.2	Develop and implement an alien invasive species control programme to manage the spread of alien invasive species onsite.	At the start of construction and duration of	SHEQ

Vulnerable sector/ component	Potential impact	No.	Detailed actions	Timeframes	Responsibility
				operational and closure phases	
	Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration, reduced runoff, and drought conditions, which can impact negatively on aquatic ecosystems (i.e. rivers, pans, and wetlands) in Lephalale.	1.2.3	Develop a water conservation/water demand management plan for the Turfvlakte Project and incorporate it into the existing water conservation/water demand management plan for Grootegeluk Coal Mine for implementation	At the start and for the duration of the operational phase	Operations
1.3 Water supply	Increases in average temperatures and number of hot days, coupled with decreasing average rainfall, can lead to increased evapotranspiration and the increase in frequency and severity of droughts. This can reduce water availability in a region which is already known to be water scarce.	1.2.3	Develop a water conservation/water demand management plan for the Turfvlakte Project and incorporate it into the existing water conservation/water demand management plan for Grootegeluk Coal Mine for implementation	At the start and for the duration of the operational phase	Operations
2. Turfvlakte Project					
2.1 Operational Phase					
Open pits	A decrease in average annual rainfall will reduce direct rainfall onto the open pits, surface runoff, and groundwater infiltration, thereby reducing pit dewatering requirements.	2.1.1	Limit the area in the immediate vicinity of the open pits that will be graded to drain towards the open pits.	Duration of the operational phase	Operations
		2.1.2	Construction of diversion channels and ditches to direct non-contact water away from the open pits.	Prior to the start of the operational phase	Engineering

Vulnerable sector/ component	Potential impact	No.	Detailed actions	Timeframes	Responsibility
		2.1.3	Use of pit floor sumps to pump pit water to Grootegeluk Coal Mine where it will be used for dust suppression and process water r.	Duration of the operational phase	Operations
Haul roads and ramps	An increase in the number of extreme rainfall days can make access roads temporarily impassable, impacting negatively on the transport of overburden, interburden, and coal from the pits to Grootegeluk Coal Mine.	2.1.4	Ensure that haul roads and ramps are maintained in good condition by attending to potholes, corrugations, and stormwater damage as soon as these develop	Duration of the operational phase	Operations
Topsoil dump	An increase in the number of extreme rainfall days can lead to increased erosion of the exposed topsoil dump, and sedimentation of the stormwater system or receiving environment.	2.1.5	Construction of upslope diversion berms to divert stormwater runoff around the topsoil dump.	Prior to the start of the operational phase	Engineering
		2.1.6	Construction of conduits to direct runoff from the topsoil dump to a stormwater outfall point.	Prior to the start of the operational phase	Engineering
Employees and contractors	An increase in average monthly temperatures and number of hot days can increase the risk of employees suffering from heat stroke and dehydration, which can adversely affect their health and well-being.	2.1.7	Develop and implement an employee health awareness program to educate Exxaro's employees and contractors about the importance of drinking water and identifying the signs of early signs of heat stroke.	Duration of the operational phase	SHEQ
Employees and contractors	Variations in climatic conditions, such as temperature, rainfall patterns, and humidity, can increase malaria transmission, which can adversely affect the health and well-being of employees and contractors.	2.1.8	Monitor malaria incident reports.	Duration of the operational phase	SHEQ
		2.1.9	If local incidents are reported, implement fogging and spraying at the mine during the wet season (September to April).	Duration of the operational phase	SHEQ

Vulnerable sector/ component	Potential impact	No.	Detailed actions	Timeframes	Responsibility
		2.1.10	Develop and implement an employee health awareness program to educate Exxaro's employees and contractors about Malaria and preventative measures.	Duration of the operational phase	SHEQ
Beneficiation plants	A decrease in average annual rainfall will reduce direct rainfall onto the main pits, surface runoff, and groundwater infiltration, thereby reducing the availability of pit water for the beneficiation plants at Grootegeluk Coal Mine.	1.2.11	Develop a water conservation/water demand management plan for the Turfvlakte Project and incorporate it into the existing water conservation/water demand management plan for Grootegeluk Coal Mine for implementation.	Duration of the operational phase	Operations
Discard dump	Marked increases in daily or seasonal temperatures will increase the rate of oxidation, thereby increasing exothermic reactions and the risk of spontaneous combustion of the coal discards in the backfill of the Grootegeluk Pit.	1.2.12	Where possible, cap each bench to minimise the exposed surface area for exothermic reactions and to prevent the ingress of oxygen and moisture.	Duration of the operational phase	Operations
		1.2.13	Annual thermographic surveys of the pit backfill to identify 'hotspots' for signs of spontaneous combustion.	Duration of the operational phase	Operations
2.2 Closure Phase					
Rehabilitated mining areas	A decrease in average annual rainfall, coupled with an increase in average monthly temperatures and evaporation rates, will reduce the water availability to the plants used in rehabilitation of mining areas. This can impact negatively on the establishment of vegetation on these areas, and their stability in the long-term.	2.2.1	Post-closure monitoring of the re-vegetated areas on an annual basis. If required, apply new topsoil, fertilise, reseed/replant, and water areas where plants have been washed away or struggling to become established.	For five-years post-closure	SHEQ

9.0 CONCLUSION

In conclusion, the projected changes in climate in the short term (2020 to 2039) and medium-term (2040 to 2059) are unlikely to have a significant direct impact on the Turfvlakte Project.

However, the projected changes in climate are likely to have a greater impact on the Turfvlakte Project indirectly due to the prevailing water scarcity in the area, which is likely to be exacerbated by the increase in average temperatures, number of hot days, and evapotranspiration, coupled with a decrease in average rainfall. As a consequence, the availability of surface water resources is likely to be reduced in the future while the demand on these finite resources is likely to increase due to population growth and economic development in the region.

As the availability of surface water resources decreases, there is likely to be increased pressure on Exxaro to not only limit water consumption to their current allocation from the Mokolo dam, but also to reduce water consumption to make more water available for other users, such as the town of Lephalale, downstream farmers, and ESKOM. In light of these risks, it is recommended that Exxaro:

- Appoint a suitably qualified service provider to undertake downscaled climate model simulations of the area in which the Turfvlakte Project and Grootegeluk Coal Mine are located to more realistically model the changes in climate, particularly in the short term and medium term
- Update the water balance of the Turfvlakte Project and Grootegeluk Coal Mine based on the findings of the downscaled climate model simulations
- Align the recommended water conservation/water demand management plan for the Grootegeluk Coal Mine, which incorporates the Turfvlakte Project, with the findings the downscaled climate model simulations and updated water balance

10.0 REFERENCES

1) Bradshaw D., Nannan N., Laubscher R., Groenewald P., Joubert J., Nojilana B., Norman R., Pieterse D., and Schneider M. (2000). *South African Burden of Disease Study: Estimates of Provincial Mortality: Limpopo 2000*.

2) CSIR (2019). *Green Book: Adapting South African Settlements to Climate Change*. www.greenbook.co.za [accessed on 21 April 2020]

3) DEA (2018). *Climate Change Bill, 2018: For public comment*. Published under General Notice 580 in Government Gazette No. 41689 of 8 June 2018

4) DEA (2012). *National Climate Change Response White Paper*. Published by Department of Environmental Affairs

5) DEA (2010). *South Africa Communication to UNFCCC*. https://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/southafricacphaccord_app2.pdf / [accessed on 21 April 2020]

6) Engelbrecht F. (2019). *Green Book: Detailed Projections of Future Climate Change over South Africa*. Technical Report. Council for Scientific and Industrial Research. Pretoria

7) Environomics, NRM Consulting and MetroGIS (2010). *Waterberg District Environmental Management Framework Report*. Prepared by Environomics, NRM Consulting and MetroGIS for the Department of Environmental Affairs

8) Hatfield Consultants and AHT Group AG (2020). *The Limpopo River Awareness Kit*. http://www.limpopo.riverawarenesskit.org/ [accessed on 09 June 2020]

9) IPCC (2014*). Climate Change 2014: Synthesis Report*. Intergovernmental Panel on Climate Change (IPCC). Geneva, Switzerland

10) Lephalale Municipality (2020). *Draft Integrated Development Plan 2020*. Lephalale Municipality

11) Limpopo DEDET (2016). *Provincial Climate Change Response Strategy*. Published by the Limpopo Department of Economic Development, Environment, and Tourism

12) Lindevall E. (2020). *Limpopo River Basin: Disaster Risk in a Changing Environment*. https://www.arcgis.com/apps/Cascade/index.html?appid=22287abd11ce4afd82fb4bfecbf11885 [accessed on 09 June 2020]

13) NDOH (2019). *Malaria Elimination Strategic Plan for South Africa 2019-2023*. National Department of Health. Pretoria

14) UNFCCC (2020a). *What is the United Nations Framework Convention on Climate Change?* https://unfccc.int/process-and-meetings/the-convention/what-is-the-united-nations-framework-convention-on-climate-change [accessed on 21 April 2020]

15) UNFCCC (2020b). *What is the Kyoto Protocol?* https://unfccc.int/kyoto_protocol [accessed on 21 April 2020]

16) UNFCCC (2020c). *What is the Paris Agreement?* https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement [accessed on 21 April 2020]

17) Urban-Econ (2014). *Waterberg LED 2014*. Prepared by Urban-Econ: Development Consultants for the Waterberg District Municipality

18) World Bank (2020). *Climate Change Knowledge Portal*. https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-historical [accessed on 21 April 2020]

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APPENDIX A

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