Climate Change Assessment for the Africa Oil South Africa Corp Block 3B/4B Offshore Exploration

Project done for Environmental Impact Management Services (EIMS)

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Report Details

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Report Title	Climate Change Assessment for the Africa Oil South Africa Corp Block 3B/4B Offshore Exploration
Date	November 2023
Client	Environmental Impact Management Services (EIMS)
Prepared by	Gillian Petzer, BEng (Chem.) (University of Pretoria), Pr. Eng.
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
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Revision Record

Revision Number	Date	Reason for Revision
Rev 0	October 2023	Draft for client review
Rev 0.1	November 2023	EIMS comments addressed

Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
Airshed	Airshed Planning Professionals (Pty) Ltd
AOI	Area of interest
AOSAC	Africa Oil South Africa Corp
AQSR	Air Quality Sensitive Receptor
AR5	5th IPCC assessment report
AR6	6th IPCC assessment report
BAU	Business-As-Usual
BRE	Building Research Establishment
CCA	Climate Change Assessment
CCRA	Climate Change Reference Atlas
CCS	Carbon Capture and Storage
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CORDEX	Coordinated Regional Downscaling Experiment
CMIP	Coupled Model Inter-comparison Projects
CSIR	Council for Scientific and Industrial Research
CVI	Coastline Vulnerability Index
DFFE	Department of Forestry, Fisheries and the Environment
EBRD	European Bank for Reconstruction and Development
ECSA	Engineering Council of South African
EIA	Environmental Impact Assessment
EIMS	Environmental Impact Management Services
GHG	Greenhouse Gas
GHGIP	National Greenhouse Gas Improvement Programme
GN	Government Notice
GPG	Good Practice Guidance
GWP	Global Warming Potential
IEM	Integrated environmental management
IFC	International Finance Corporation
H_2O	Water vapour
HAZID	Hazard identification study
HAZOP	Hazard and operability study
HFCs	Hydrofluorocarbons
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Use

MGO	Marine gas oil
NAAQS	National Ambient Air Quality Standards (South Africa)
NACA	National Association for Clean Air
NDC	Nationally Determined Contributions
NEMA	National Environmental Management Act
NEM:AQA	National Environmental Management: Air Quality Act
NGERS	National Greenhouse Gas Emission Reporting Regulations
N_2O	Nitrous oxide
NO_x	Nitrogen oxides
O_3	Ozone
PFCs	Perfluorocarbons
PPP	Pollution Prevention Plan
PV	Photovoltaic
RCP	Representative Concentration Pathways
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SA	South Africa(n)
SAAELIP	South African Atmospheric Emission Licensing and Inventory Portal
SAAQIS	South African Air Quality Information System
SAGERS	South African Greenhouse Gas Emissions Reporting System
SAWS	South African Weather Service
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
SSP	Shared Socioeconomic Pathway
TCFD	Taskforce for Climate-related Financial Disclosures
UNFCCC	United Nations Framework Convention on Climate Change
WCG	Western Cape Government
WCRP	World Climate Research Programme
WGCM	Working Group on Coupled Modelling

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Environmental Impact Management Services (EIMS) to conduct a climate change assessment (CCA) for the Africa Oil South Africa Corp Block3B/4B Offshore Exploration.

With the exploration being offshore, the nearest identified air quality sensitive receptors (AQSRs) include coastal towns along the west coast, with the nearest town being Paternoster and Saldanha Bay (120 km from the closest point).

The assessment was based on Scope 1 greenhouse gas (GHG) emissions for the proposed exploration survey in a portion of Block 3B/4B. The calculated carbon dioxide equivalent (CO_2-e) emissions were estimated at a total of 31.87 kilotonne (kt). The GHG emissions were estimated using South African (SA) specific caloric values and densities for fuels (where available) and the Intergovernmental Panel on Climate Change (IPCC) emission factors.

Based on the published 2020 National GHG annual Inventory for South Africa, the maximum total CO_2-e emissions from the Project, assuming a maximum survey duration of 84 days, would contribute approximately 0.008% to the 2020 South African "energy" sector total of 379 505.2 kt CO_2-e and represent a contribution of 0.007% to the 2020 National GHG inventory total of 468 811.7 kt CO_2-e (excluding Forestry and Other Land Use (FOLU)).

The European Bank for Reconstruction and Development (EBRD) classifies projects contributing more than 25 kt CO_2-e per year to have significant GHG emissions (EBRD 2019). Although the GHG emissions are expected to be above this threshold, it is less than the Department of Forestry, Fisheries and the Environment (DFFE) Pollution Prevention Plan (PPP) requirement threshold of 100 kt CO_2-e. Given that, the negative impact is of low intensity, national extent, irreversible but of short duration, the environmental risk is **low** (due to its limited period of emission and future uptake by vegetation).

Since the Project is of a temporary nature and expected to be completed in the near future, changes in meteorological parameters are not expected to have a significant impact on the Project.

The means to minimise air emissions from the Project would be achieved by implementing a maintenance plan to ensure all ship engines and boilers receive adequate maintenance to minimise unburnt fuel released to the atmosphere and maximize energy efficiency.

The National Environmental Management: Air Quality Act (NEM:AQA) also provides for the monitoring and reporting of GHG emissions. As per the DFFE National Greenhouse Gas Emission Reporting Regulations and the Methodological Guidelines for Quantifying of GHG Emissions (2022), the Intergovernmental Panel on Climate Change (IPCC) default emission factors are to be used together with country-specific density and calorific values for the fuel used. The DFFE Regulations require that carbon monoxide (CO_2) and methane (CH_4) levels (calculated based on Tier 2 or 3 methodologies) be reported on annually via the South African Greenhouse Gas Emissions Reporting System (SAGERS).

Carbon tax (Carbon Tax Act (Act 15 of 2019)) needs to be estimated based on the requirements and tax allowances. The *Declaration of Greenhouse Gases as Priority Pollutants* require certain processes to submit a PPP to the Minister for approval. The production process does not involve the emissions of GHG in excess of PPP threshold of 100 kt. Thus, although reporting is required via SAGERS, it may be concluded that the current project does not require a PPP.

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1 INTRODUCTION

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Environmental Impact Management Services (EIMS) to conduct a climate change assessment (CCA) for the Africa Oil South Africa Corp Block3B/4B Offshore Exploration.

2 DOCUMENT STRUCTURE

This report has been compiled in accordance with the Environmental Impact Assessment (EIA) Regulations, 2017 (South Africa, 2017) as part of the National Environmental Management Act (NEMA) of 1998. A summary of the report structure, and the specific sections that correspond to the applicable regulations, is provided in Table 2-1 below.

Table 2-1: Report structure (NEMA EIA regulations 2017)

Environmental Regulation	Description	Section in Report
Appendix 6 (1) (a)	Details of - (i) the specialist who prepared the report, and (ii) the expertise of that person to compile a specialist report including curriculum vitae.	Report Details Section 3: Specialist Details Appendix B
Appendix 6 (1) (b)	A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details Appendix A
Appendix 6 (1) (c)	An indication of the scope of, and the purpose for which, the report was prepared.	Section 4: Terms of Reference
Appendix 6 (1) (cA)	An indication of quality and age of base data used.	Section 8: Receiving Environment
Appendix 6 (1) (cB)	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change.	Section 9: Impact on the Receiving Environment
Appendix 6 (1) (d)	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment.	A site investigation was not undertaken. Description of the current land use in the region, and meteorological data used in the study are considered representative of all seasons. Section 9: Impact on the Receiving Environment
Appendix 6 (1) (e)	A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 7: Methodology
Appendix 6 (1) (f)	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives.	Section 9: Impact on the Receiving Environment
Appendix 6 (1) (g)	An identification of any areas to be avoided, including buffers.	Section 9: Impact on the Receiving Environment
Appendix 6 (1) (h)	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Section 9: Impact on the Receiving Environment
Appendix 6 (1) (i)	A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 12: Assumptions, Uncertainties and Gaps in Knowledge
Appendix 6 (1) (j)	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 11: Conclusion
Appendix 6 (1) (k)	Any mitigation measures for inclusion in the EMPr.	Section 11: Conclusion

Environmental Regulation	Description	Section in Report
Appendix 6 (1) (l)	Any conditions for inclusion in the environmental authorisation	Section 11: Conclusion
Appendix 6 (1) (m)	Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 11: Conclusion
Appendix 6 (1) (n)	A reasoned opinion – (i) as to whether the proposed activity, activities or portions thereof should be authorised; regarding the acceptability of the proposed activity or activites; and (ii) if the opinion is that the proposed activity, activites or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan.	Section 11: Conclusion
Appendix 6 (1) (o)	A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable.
Appendix 6 (1) (p)	A summary and copies of any comments that were received during any consultation process.	Not applicable.
Appendix 6 (1) (q)	Any other information requested by the competent authority.	Not applicable.

3 Specialist Details

Report author: Gillian Petzer (Pr. Eng., BEng Chemical (University of Pretoria))

Gillian Petzer started her professional career in Air Quality in 2000 when she joined the Building Research Establishment (BRE) in the United Kingdom after completing her Bachelor's Degree in Chemical Engineering at the University of Pretoria. She joined Airshed Planning Professionals in 2003 and is now a senior consultant at the company.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

Gillian is also actively involved in the National Association for Clean Air (NACA) and is a member of the Institution of Chemical Engineers (IChemE) and is a registered Professional Engineer with the Engineering Council of South African (ECSA) (registration no. 20170315).

4 TERMS OF REFERENCE

The following tasks, typical of a climate change assessment, were included in the scope of work:

- Study of the receiving environment including the identification of air quality-sensitive receptors (AQSRs) and the collection and analysis of historic and projected weather data;
- Establishing the legislative and regulatory context, including the consideration of the National Greenhouse Gas (GHG) Inventory;
- Quantification of all sources of GHG emissions associated with the proposed Project; and
- A climate change assessment report.

5 PROJECT DESCRIPTION

Block 3B/4B is situated between latitudes 31°S and 33°S (see Figure 5-2) on the continental shelf in water depths ranging from 200 m to 2 000 m. Block 3B/4B is located approximately 120 km west of St Helena Bay and approximately 145 km south-west of Hondeklip Bay off the West Coast of South Africa. The area of primary interest in the north of this block, but this could also cover other areas in future. As part of the process of applying for the Exploration Right, the JV Partners undertook and completed the reprocessing project covering 2 000 km^2, which is a subset of the 10 000 km^2 BHP/Shell 3D seismic datasets, focussed primarily on the most northern portion of Block 3B/4B. Block 3B/4B covers an area of approximately 11 100 km^2, and is adjacent to the Namaqualand and West Coast District Municipalities. The Area of Interest for drilling is located in the northern portion of the licence area and covers 9 711.21 km^2 ranging in water depths between 1 000 m and 3 000 m.

The project description below is summarised from the Scoping Report. For a full project description please refer to the relevant section in the ESIA Report.

Hydrocarbon deposits occur in reservoirs in sedimentary rock layers. Being lighter than water they accumulate in traps where the sedimentary layers are arched or tilted by folding or faulting of the geological layers. Exploration drilling activities are one of the primary geophysical methods for locating such deposits. The below activities are expected to be undertaken as part of the proposed exploration for oil and gas.

5.1 Pre-Drilling Surveys

Pre-drilling surveys will be undertaken prior to drilling in order to confirm baseline conditions at the drill site and to identify and delineate any seabed and sub-seabed geo-hazards that may impact the proposed exploration drilling operations. Pre-drilling surveys may involve a combination of sonar surveys, sediment sampling, water sampling and ROV activities.

5.1.1 Sonar Surveys

Pre-drilling sonar surveys may involve multi- and single beam echo sounding and sub-bottom profiling. These surveys would not be limited to a specific time of the year but would be of short duration (around 10 days or shorted per survey) and focused on selected areas of interest within the block. The interpretation of the survey would take up to four weeks to complete.

5.1.2 Echo Sounders

The majority of hydrographic depth/echo sounders are dual frequency, transmitting a low frequency pulse at the same time as a high frequency pulse. Dual frequency depth/echo sounding has the ability to identify a vegetation layer or a layer of soft mud on top of a layer of rock. Africa Oil South Africa Corp (AOSAC) is proposing to utilise a single beam echo-sounder with a frequency range of 38 to 200 kHz. In addition, it is proposed to also utilise multibeam echo sounders (70 - 100 kHz range and 200 dB re 1µPa at 1m source level) that are capable of receiving many return "pings". This system produces a digital terrain model of the seafloor.

5.1.3 Sub-Bottom Profilers

Sub-bottom profilers are powerful low frequency echo-sounders that provide a profile of the upper layers of the ocean floor. Bottom profilers emit an acoustic pulse at frequencies ranging between 2 and 16 kHz, typically producing sound levels in the order of 200-230 db re 1µPa at 1m.

5.1.4 Seabed Sediment Coring

Seabed sediment sampling may involve the collection of sediment samples in order to characterise the seafloor and for laboratory geochemical analyses in order to determine if there is any naturally occurring hydrocarbon seepage at the seabed or any other type of contamination prior to the commencement of drilling.

No specific target area has as yet been identified for the sediment sampling. It is currently anticipated that up to 20 samples could be taken across the entire area of interest potentially removing a cumulative volume of ~ 35 m^3. The sediment sampling process would take between three to five weeks to complete, depending on weather conditions.

Piston and box coring (or grab samples) techniques may be used to collect the seabed sediment samples. These techniques are further described below.

5.1.5 Piston coring

Piston coring (or drop coring) is one of the more common methods used to collect seabed geochemical samples. The piston coring rig is comprised of a trigger assembly, the coring weight assembly, core barrels, tip assembly and piston. The core barrels are 6 - 9 m in lengths with a diameter of 10 cm. The recovered cores are visually examined at the surface for indications of hydrocarbons (gas hydrate, gas parting or oil staining) and sub-samples retained for further geochemical analysis in an onshore laboratory.

5.1.6 Box Coring

Box corers are lowered vertically to the seabed from a survey vessel by. At the seabed the instrument is triggered to collect a sample of seabed sediment. The recovered sample is completely enclosed thereby reducing the loss of finer materials during recovery. On recovery, the sample can be processed directly through the large access doors or via complete removal of the box and its associated cutting blade. AOSAC is proposing to take box core samples (50 cm x 50 cm) at a depth of less than 60 cm.

5.2 Well Location and Drilling Programme

AOSAC is proposing to drill up to five exploration wells within an Area of Interest (AOI) within Block 3B/4B. The expected target drilling depth is not confirmed yet and a notional well depth of 3 570 m below sea floor (Water depth range 500 -1700m) is assumed at this stage. It is expected that it would take approximately three to four months to complete the physical drilling and testing of each well (excluding mobilisation and demobilisation). AOSAC's strategy for future drilling is that drilling could be undertaken throughout the year (i.e. not limited to a specific seasonal window period).

The schedule for drilling the wells is not confirmed yet; however, the earliest anticipated date for commencement of drilling is between first quarter of 2024 (Q1 2024) and third quarter of 2024 (Q3 2024).

5.3 Main Project Components

5.3.1 Drilling Unit Operations

Various types of drilling technology can be used to drill an exploration well (e.g. barges, jack-up rigs, semi-submersible drilling units (rigs) and drill-ships) depending on, inter alia, the water depth and marine operating conditions experienced at the well site. Based on the anticipated sea conditions, AOSAC is proposing to utilise a semi-submersible drilling unit or a drill-ship, both with dynamic positioning system suitable for the deep-water harsh marine environment. The final rig selection will be made depending upon availability and final design specifications.

- A semi-submersible drilling unit is essentially a drilling rig located on a floating structure of pontoons. When at the well location, the pontoons are partially flooded (or ballasted), with seawater, to submerge the pontoons to a pre-determined depth below the sea level where wave motion is minimised. This gives stability to the drilling vessel thereby facilitating drilling operations.

- A drillship is a fit for purpose-built drilling vessel designed to operate in deep water conditions. The drilling "rig" is normally located towards the centre of the ship with support operations from both sides of the ship using fixed cranes. The advantages of a drillship over the majority of semi-submersible units are that a drillship has much greater storage capacity and is independently mobile, not requiring any towing and reduced requirement of supply vessels.

5.3.2 Support Vessels

The drilling unit would be supported / serviced by up to two support vessels, which would facilitate equipment, material and waste transfer between the drilling unit and onshore logistics base. A supply vessel will always be on standby near the drilling unit to provide support for firefighting, oil containment / recovery, rescue in the unlikely event of an emergency and supply any additional equipment that may be required. Support vessels can also be used for medical evacuations or transfer of crew if needed.

5.3.3 Helicopters

Transportation of personnel to and from the drilling unit would be provided by helicopter from Springbok Airport (fixed wing trip from Cape Town) using local providers. It is estimated that there may be up to four return flights per week between the drilling unit and the helicopter support base at Springbok (i.e. 17 weeks (˜120 days) x 4 = 68 trips per well). The helicopters can also be used for medical evacuations from the drilling unit to shore (at day- or night-time), if required, in which case the flights are likely to be directly to Cape Town.

5.3.4 Onshore Logistics Base

The primary onshore logistics base will most likely be located at the Port of Cape Town (preferred option), but alternatively at the Port of Saldanha.

The shore base would provide for the storage of materials and equipment that would be shipped to the drilling unit and back to storage for onward international freight forwarding. The shore base would also be used for offices, waste management services, bunkering vessels, and stevedoring / customs clearance services.

5.4 Mobilisation Phase

The mobilisation phase will entail the required notifications, establishment of the onshore base, appointment of local service providers, procurement and transportation of equipment and materials from various ports and airports, accommodation arrangements and transit of the drilling unit and support vessels to the drilling area.

The drilling unit and supply vessels could sail directly to the well site from outside South African waters or from a South African port, depending on which drilling unit is selected, and where it was last used.

Core specialist and skilled personnel would arrive in South Africa onboard the drilling unit and the rest of the personnel will be flown to Cape Town.

Drilling materials, such as casings, mud components and other equipment and materials will be brought into the country on the drilling unit itself or imported *via* a container vessel directly to the onshore logistics base from where the supply vessels will transfer it to the drilling unit. Cement and chemicals will be sourced locally.

5.5 Operation Phase

5.5.1 Final Site Selection and Seabed Survey

The selection of the specific well locations will be based on a number of factors, including further detailed analysis of the seismic and pre-drilling survey data and the geological target. A Remote Operating Vehicle (ROV) will be used to finalise the well position based on inter alia the presence of any seafloor obstacles or the presence of any sensitive features that may become evident.

5.5.2 Well-drilling Operation

The well will be created by drilling a hole into the seafloor with a drill bit attached to a rotating drill string, which crushes the rock into small particles, called “cuttings”. After the hole is drilled, casings (sections of steel pipe), each slightly smaller in diameter, are placed in the hole and permanently cemented in place (cementing operations are described below). The hole diameter decreases with increasing depth.

The casings provide structural integrity to the newly drilled wellbore, in addition to isolating potentially dangerous high-pressure zones from each other and from the surface. With these zones safely isolated, and the formation protected by the casing, the well will be drilled deeper with a smaller drill bit, and also cased with a smaller sized casing. For the current project, it is anticipated that there will be five sets of subsequently smaller hole sizes drilled inside one another, each cemented with casing, except the last phase that will remain an open hole.

Drilling is essentially undertaken in two stages, namely the riserless and risered drilling stages (Figure 5-1). The well design ultimately depends upon factors such as planned depths, expected pore pressures and anticipated hydrocarbon-bearing formations. Several types of drilling fluids with different compositions and densities would be used for drilling operations.

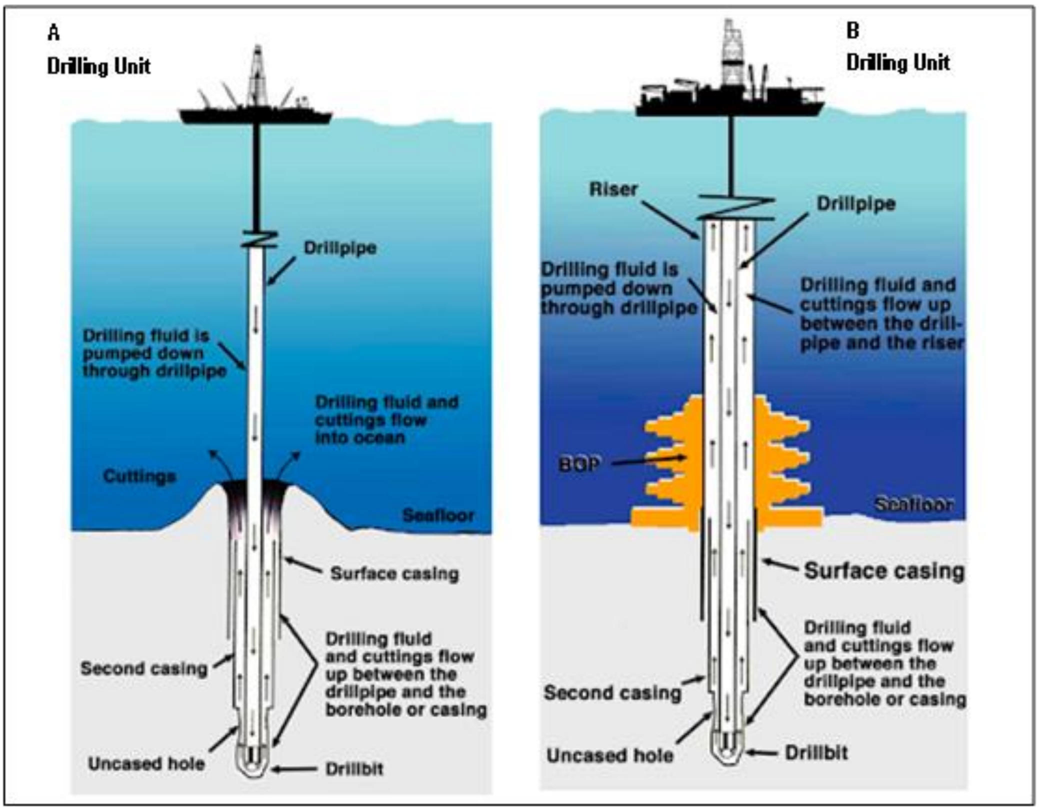


Figure 5-1: Drilling stages: (a) Riserless Drilling Stage; and (b) Risered Drilling Stage.

5.5.3 Well Logging and Testing

Once the target depth is reached, the well would be logged and could be tested dependent on the drilling results.

Well logging involves the evaluation of the physical and chemical properties of the sub-surface rocks, and their component minerals, including water, oil and gas to confirm the presence of hydrocarbons and the petrophysical characteristics of rocks. It is undertaken during the drilling operation using Wireline Logging or Logging While Drilling (LWD) to log core data from the well. Information from engineering and production logs, as well as mud logging, may also be used.

Vertical Seismic Profiling (VSP) is an evaluation tool used to generate a high-resolution seismic image of the geology in the well's immediate vicinity. The VSP images are used for correlation with surface seismic images and for forward planning of the drill bit during drilling. VSP uses a small airgun array with a gun pressure of 450 per square inch (psi), which is operated from the drilling unit at a depth of between 7 m and 10 m. During VSP operations, four to five receivers are positioned in a section of the borehole and the airgun array is discharged approximately five times at 20 second intervals at each station. The generated sound pulses are reflected through the seabed and are recorded by the receivers to generate a profile along a 60 to 75 m section of the well. This process is repeated for different stations in the well and may take up to six hours to complete approximately 125 shots, depending on the well's depth and number of stations being profiled.

Well or flow testing is undertaken to determine the economic potential of the discovery before the well is either abandoned or suspended. One test would be undertaken per exploration well should a resource be discovered and up to two tests per appraisal well. Each test would take up to 7 days to complete (5 days of build-up and 2 days of flowing and flaring). For well flow-testing, hydrocarbons would be burned at the well site. A high-efficiency flare is used to maximise combustion of the hydrocarbons. Burner heads which have a high burning efficiency under a wide range of conditions will be used.

The volume of hydrocarbons (to be burned) and possible associated produced water from the reservoir which could be generated during well testing cannot be reliably predicted due to variations in gas composition, flow rates and water content. Burners are manufactured to ensure emissions are kept to a minimum. The estimated volume of hydrocarbons to be burned cannot be predicted with much accuracy because the actual test requirements can only be established after the penetration of a hydrocarbon-bearing reservoir. However, an estimated 10 000 bbl oil could be flared per test, i.e. up to 20 000 bbl over the two tests associated with an appraisal well. If produced water is generated during well testing, it will be separated from the hydrocarbons.

5.5.4 Well Sealing and Plugging

The purpose of well sealing and plugging is to isolate permeable and hydrocarbon bearing formations. Well sealing and plugging aims to restore the integrity of the formation that was penetrated by the wellbore. The principal technique applied to prevent cross flow between permeable formations is plugging of the well with cement, thus creating an impermeable barrier between two zones.

Once drilling and logging have been completed, the exploration wells will be sealed with cement plugs, tested for integrity and abandoned according to international best practices. Cement plugs will be set to isolate hydrocarbon bearing and / or permeable zones and cementing of perforated intervals (e.g. from well logging activities) will be evaluated where there is the possibility of undesirable cross flow. These cement plugs are set in stages from the bottom up. Three cement plugs would be installed: i.e. one each for isolation of the deep reservoir and the main reservoir; and a third as a second barrier for the main reservoir.

The integrity of cement plugs can be tested by a number of methods. The cement plugs will be tag tested (to validate plug position) and weight tested, and if achievable then a positive pressure test (to validate seal) and/or a negative pressure test will be performed. Additionally, a flow check may be performed to ensure sealing by the plug. Once the well is plugged, seawater will be displaced before disconnecting the riser and the BOP.

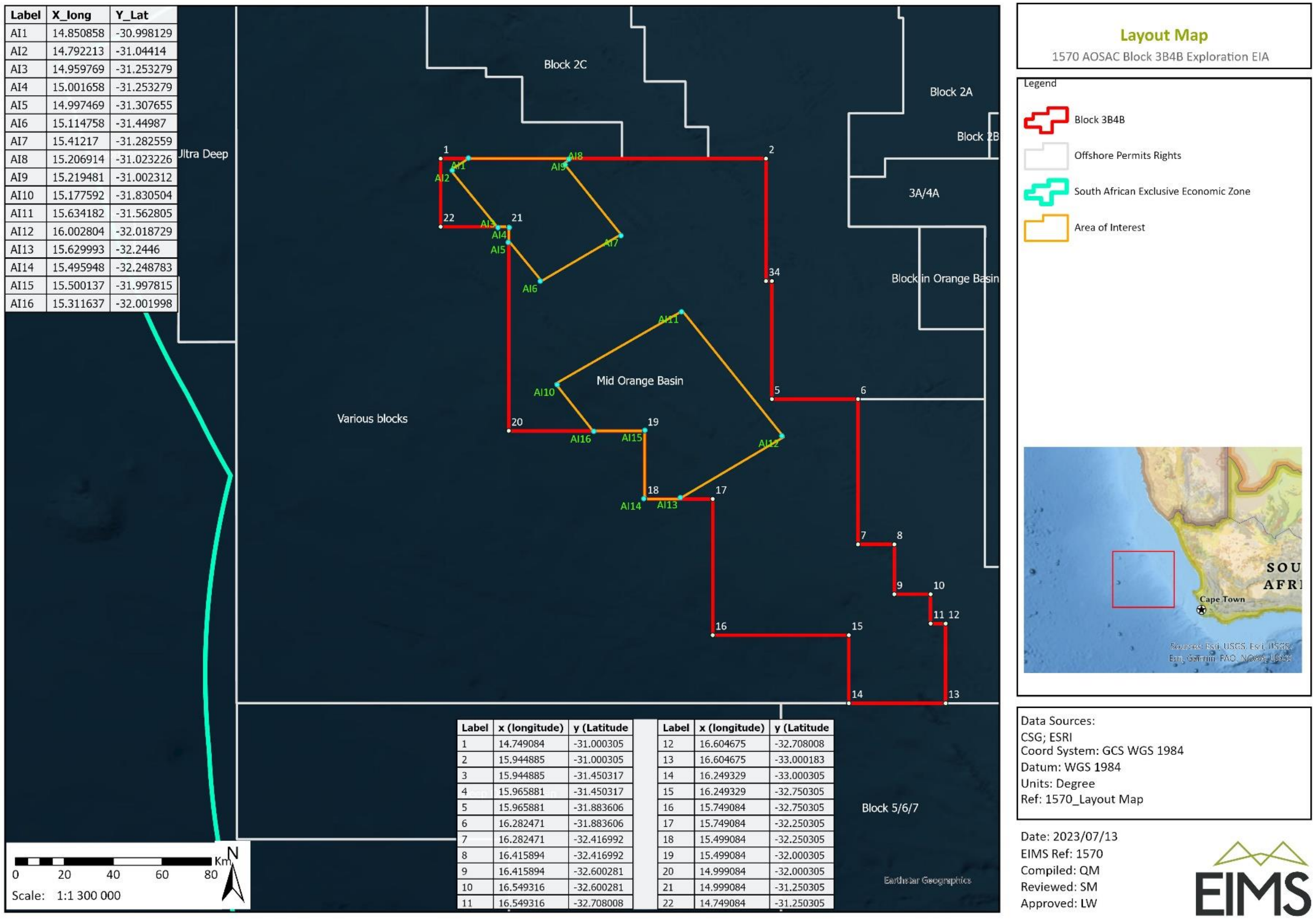
5.5.5 Demobilisation Phase

After the exploration wells have been sealed, tested for integrity and abandoned, the intention is to remove the wellheads from the sea floor on non-productive wells. On productive wells, it may be decided to abandon the wellheads on the seafloor after installation of over trawlable protective equipment. The risk assessment criteria will consider factors such as the water depth and use of the area by other sectors (e.g., fishing).

Monitoring gauges to monitor pressure and temperature through wireless communication with frequencies between the transmitter and the receiver in the 12.75 to 21.25 kHz range may be installed on wells where AOSAC will return in the future for appraisal / production purposes. The gauges will be placed and remain on the wellhead. Monitoring gauges will not be installed on exploration wells which are earmarked for abandonment

With the exception of the over trawlable protective equipment over abandoned wellheads and drilling discharges deposited on the seabed, no further physical remnants of the drilling operation will be left on the seafloor. A final clearance survey check will be undertaken using an ROV. The drilling unit and supply vessels will demobilise from the offshore licence area and either mobilise to the following drilling location or relocate into port or a regional base for maintenance, repair or resupply.

Refer to Figure 5-2 below for an indication as to where the proposed drilling facilities will be located.



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AI13	15.629993	-32.2446
AI14	15.495948	-32.248783
AI15	15.500137	-31.997815
AI16	15.311637	-32.001998

Label	x (longitude)	y (Latitude	Label	x (longitude)	y (Latitude
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5	15.965881	-31.883606	16	15.749084	-32.750305
6	16.282471	-31.883606	17	15.749084	-32.250305
7	16.282471	-32.416992	18	15.499084	-32.250305
8	16.415894	-32.416992	19	15.499084	-32.000305
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10	16.549316	-32.600281	21	14.999084	-31.250305
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Figure 5-2: Locality map

6 LEGISLATIVE AND POLICY FRAMEWORK IN TERMS OF CLIMATE CHANGE AND GHGS

There is a requirement to consider climate change in the EIA process. It is firstly necessary to understand South Africa's current policies and commitments towards climate change mitigation and adaption. For this purpose, project activities must be identified and GHG emissions quantified to enable the establishment of the project's significance. As a benchmark for comparison, it is also necessary to provide South Africa's total GHG emissions and its contribution to the global GHG inventory.

GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the earth's atmosphere. Moreover, there are several entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, addressed under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007). Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 406 ppm in early 2017 (NOAA, 2017). This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle (NOAA, 2017). Anthropogenic CO_2 emissions (i.e., emissions produced by human activities) come from combustion of fossil fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture (IPCC, 2007).

6.1 South African National Climate Change Response Policy

The National Climate Change Response White Paper of 2014, stated that in responding to climate change, South Africa has two objectives:

- to contribute to the global effort in stabilising GHG emissions at a level that avoids dangerous anthropogenic interference with the climate system and
- to manage the inevitable climate change impacts

The White Paper proposed mitigation actions, especially a departure from coal-intensive electricity generation, be implemented in the short- and medium-term to match the GHG trajectory range. Peak GHG emissions were expected between 2020 and 2025 before a decade long plateau period and subsequent reductions in GHG emissions. The White Paper also highlighted the co-benefits of reducing GHG emissions by improving air quality, as well as minimising respiratory diseases by reducing ambient particulate matter, O_3 and sulfur dioxide (SO_2) concentrations to levels in compliance with the National Ambient Air Quality Standards (NAAQS) by 2020. In order to achieve these objectives, the Department of Forestry, Fisheries and the Environment (DFFE) established a national GHG emissions inventory, which report through the South African Air Quality Information System (SAAQIS).

The Western Cape Government (WCG) similarly proposed the Western Cape Climate Change Response Strategy during February 2014 in recognition to the urgency to reduce GHG emissions and adapt to global climate change. In contributing to global and national efforts to mitigate climate change and build resilience, the approach of the proposed strategic takes a two-pronged approach to addressing climate change:

- Mitigation: Contribute to national and global efforts to significantly reduce GHG emissions and build a sustainable low carbon economy, which simultaneously addresses the need for economic growth, job creation and improving socio-economic conditions. Most of the Western Cape's emissions arise from energy generation (electricity and liquid fuels) and use (industry and transport), and mitigation actions therefore need to focus on these areas. The main opportunities for mitigation therefore include energy efficiency, demand-side management and moving to a less emissions-intensive energy mix, which is dominated by electricity, coal, petrol, and diesel (in that order).

- Adaptation: Reduce climate vulnerability and develop the adaptive capacity of the Western Cape's economy, its people, its ecosystems and its critical infrastructure in a manner that simultaneously addresses the province's socio-economic and environmental goals.

6.2 Nationally Determined Contribution

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC), as a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable. By 1995, countries launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed country parties to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. As agreed in Doha in 2012, the second commitment period began on 1 January 2013 and would have ended in 2020 (UNFCCC, 2017), but due to lack of ratification has not come into force. The Paris Agreement (2016) builds upon the Convention and – for the first time – brought all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charted a new course in the global climate effort. The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2.0°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. All signed parties to the Paris Agreement are required to put forward proposed climate change minimisation efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts. There will also be a global stocktake every five years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties.

As of February 2020, 189 Parties of the 197 Parties to the UNFCCC Convention, including South Africa, had ratified the Paris agreement. As a non-Annex I country, South Africa is not bound to commit to a cap or reduce GHG emissions; however, a pledge was made in 2009 (Copenhagen 2009) to reduce emissions by 34% below business-as-usual (BAU) emissions by 2020 and 42% below BAU by 2025. The original NDC was submitted to the UNFCCC and became the first NDC on 1 November 2016 (RSA 2016). This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCCC. This document describes South Africa's NDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions with updated revisions to the adaptation goals and mitigation targets.

All parties to the UNFCCC were updating their NDC's in the run-up to the 26th international climate change conference that was held in Glasgow, Scotland, in November 2021. The updated draft NDC[1], was approved by Cabinet on 24 March 2021 and released for public comment. The committed 2030 target range (398 - 440 Mt CO_2-e) is an ambitious improvement on the current NDC target, i.e., the upper range of this proposed 2030 target range represents a 28% reduction in GHG emissions from the 2015 NDC targets. These original goals were ambitious and South Africa subsequently shifted from BAU-based

[1] This NDC is not the *second* NDC – this will be communicated in 2025.

targets for 2020 and 2025 in terms of the Cancun Agreement under the UNFCCC, to absolute GHG emissions targets under the Paris Agreement.

As part of the updated adaption portion of the NDC the following goals have been assembled:

- Goal 1: Enhance climate change adaptation governance and legal framework.
- Goal 2: Develop an understanding of the impacts on South Africa of 1.5 and 2°C global warming and the underlying global emission pathways through geo-spatial mapping of the physical climate hazards, and adaptation needs in the context of strengthening the key sectors of the economy. This will provide the scientific basis for strengthening the national and provincial governments' readiness to respond to climate risk.
- Goal 3: Implement National Climate Change Adaptation Strategy adaptation interventions for the period 2021 to 2030, where priority sectors have been identified as biodiversity and ecosystems, water, health, energy, settlements (coastal, urban, rural), disaster risk reduction, transport infrastructure, mining, fisheries, forestry and agriculture.
- Goal 4: Mobilise funding for adaptation implementation through multilateral funding mechanisms.
- Goal 5: Quantify and acknowledge national adaptation and resilience efforts.

As part of the mitigation portion of the NDC, the following have been, or can be, implemented at national level:

- At the time of writing, a total of 129 (9 910.37 MW) renewable energy Independent Power Producer projects as part of a Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) have been awarded. Of these projects, a total capacity of 6 200 MW renewable energy has been installed (or 5% of South Africa's energy supply)
- Creation of a "Green Climate Fund" to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- Decarbonising electricity by 2050.
- Implementing Carbon Capture and Sequestration (or Carbon Capture and Storage) (CCS).
- Supporting the use of electric and hybrid electric vehicles.
- Reduction of emissions achieved through the use of energy efficient lighting; variable speed drives and efficient motors; energy efficient appliances; solar water heaters; electric and hybrid electric vehicles; solar photovoltaic (PV); wind power; CCS; and advanced bioenergy.
- Updating targets based on revised 100-year global warming potential (GWP) factors (published in the Annex to decision 18/CMA.1 of the IPCC 5th Assessment Report (AR5) and based on exclusion of land sector emissions arising from natural disturbance.

The updated NDC mitigation targets, consistent with South Africa's fair share, are presented in Table 6-1.

Table 6-1: South Africa's NDC mitigation targets

Year	Target	Corresponding period
2025	South Africa's annual GHG emissions will be in a range between 398 - 510 Mt CO_2-e.	2021-2025
2030	South Africa's annual GHG emissions will be in a range between 398 - 440 Mt CO_2-e.	2026-2030

Note:
"GHG emissions" are defined as total net GHG emissions as specified in the national inventory report for 2030, including all sectors, and excluding emissions from natural disturbances in the land sector.

The GWP is the potential of an emitted gas to cause global warming relative to CO_2. This converts the emissions of all GHGs to the equivalent amount of CO_2 or CO_2-e. Although the GWP for the various pollutants are provided as ranges by the IPCC, to standardise, the South African National GHG reporting guidelines state that the following GWP values be used for reporting:

- CH_4 emissions should have a multiplier of 23; and
- N_2O emissions should have a multiplier of 296 (SA Technical Guidelines for Monitoring, Reporting and Verification of GHG Emissions (MG-2022.1 August 2022 Annexure H (DFFE, 2022))[2]

A substance's GWP is based on the energy absorbed over a period and therefore depends on the number of years over which the potential is calculated. The GWP value therefore depends on how the gas concentration decays over time in the atmosphere. GWPs based on a shorter timeframe will be larger for gases with lifetimes shorter than that of CO_2, and smaller for gases with lifetimes longer than CO_2. For example, for CH_4, which has a short lifetime, the AR5 100-year GWP of 28 is much less than the 20-year GWP of 84. N_2O, on the other hand, has a long lifetime, and the AR5 100-year GWP of 265 is nearly the same as the 20-year GWP of 264. The 100- year GWP is the most used and is also adopted in the National GHG reporting guidelines. The establishment of the GWP is an ongoing process, as is evident with the different values adopted in AR5 and sixth assessment (AR6) reports, respectively[3]. This study follows the approach stipulated in National GHG reporting guidelines, i.e., a CH_4 GWP of 23 and a N_2O GWP of 296.

6.3 National GHG Emissions Inventory

South Africa is perceived as a global climate change contributor and is undertaking steps to mitigate and adapt to the changing climate. DFFE is tasked as the lead climate change institution and is required to coordinate and manage climate related information such as development of mitigation, monitoring, adaption and evaluation strategies. This includes the establishment and updating of the National GHG Inventory. The National Greenhouse Gas Improvement Programme (GHGIP) has been initiated; it includes sector specific targets to improve methodology and emission factors used for the different sectors as well as the availability of data. The 2020 National GHG Inventory (DFFE, 2022), which includes inventories from 2000 to 2020, was prepared using the 2006 IPCC Guidelines (IPCC, 2006) and IPCC Good Practice Guidance (GPG) (IPCC 2000; IPCC 2003; IPCC 2014). The national GHG inventory covers four sectors, namely:

- Energy, including:
  - Exploration and exploitation of primary energy sources;
  - Conversion of primary energy sources into more useable energy forms in refineries and power plants;
  - Transmission and distribution of fuels; and
  - Final use of fuels in stationary and mobile applications.
- Industrial Process and Product Use (IPPU).
- Agriculture, Forestry and Other Land Use (AFOLU).
- Waste.

[2] These GWPs are different from AR5, viz 28 for CH_4 and 265 for N_2O, respectively.

[3] In the latest IPCC assessment, (IPCC 6th Assessment Report), the GWP for CH_4 has been estimated as 27.2 (non-fossil fuel) and 29.8 (fossil fuel) with an uncertainty of ±11. The GWP for N_2O has been estimated as 273 with an uncertainty of ±130. The IPCC also provides GWP for other periods, including 20 years and 500 years. With the above GWP for CH_4 (fossil fuel), its presence therefore has an estimated warming potential of 29.8±11 over 100 years, but 82.5±25.8 over 20 years; conversely N_2O has a GWP of 273±130 over both 20 and 100 years.

The latest report covers sources of GHG emissions, and removals by sinks, resulting from human or anthropogenic activities for the major GHGs: CO_2, CH_4, N_2O, PFCs, and HFCs. Indirect greenhouse gases – carbon monoxide (CO) and oxides of nitrogen (NO_X) – are also included for biomass burning. SF_6 emissions have not yet been included due to a lack of data.

The annual variation in the South African national GHG inventory from 2000 to 2020 is provided in Figure 6-1. According to the 2020 National GHG Inventory (DFFE, 2022) the total GHG emissions for 2020 were estimated at 468 811.7 kilo tonne (kt)[4] CO_2-e (excluding Forestry and Other Land Use (FOLU)[5]) and 442 125.1 kt CO_2-e (including FOLU)) (Table 6-2).

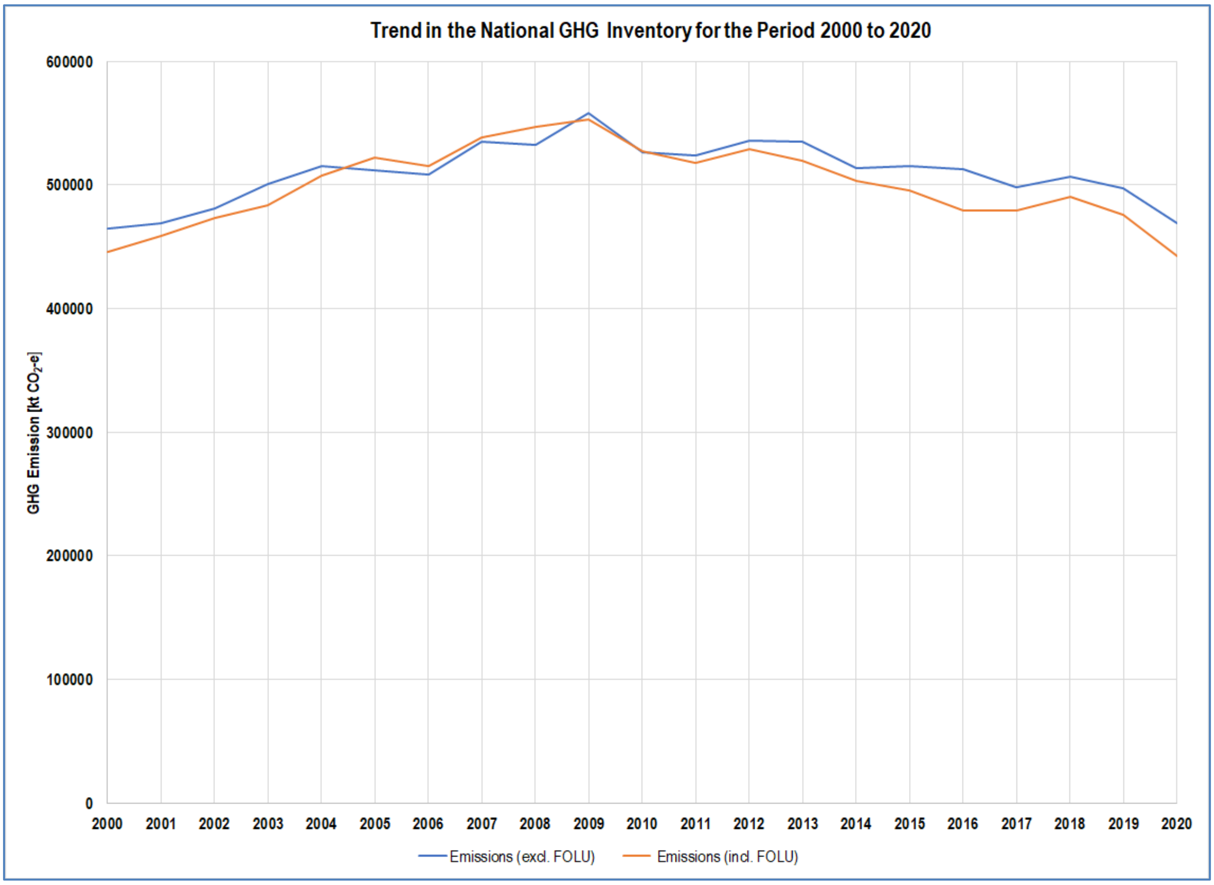


Figure 6-1: Annual trend in the South African national GHG emission inventory from 2000 to 2020 (note: FOLU is estimated to be a net carbon sink) (Source: DFFE 2022)

Table 6-2: Gross and net GHG emissions in South Africa for 2000 and 2020 based on SAR GWP values (DFFE 2022)

Sector	2000 Emissions Inventory		2020 Emissions Inventory		Change kt CO_2-e	% Change 2000 to 2020
	GHG [kt CO_2-e]	% Contribution by Sector	GHG [kt CO_2-e]	% Contribution by Sector		
Energy	371 344.6	80 - 83%	379 505.2	81 - 86%	8 160.6	2.2%
IPPU	32 955.2	7.1 – 7.4%	25 486.1	5.4 – 5.8%	-7 469.1	-22.7%
AFOLU (excluding FOLU)	42 439.1	9.1%	40 774.6	8.7%	-1 664.5	-3.9%
AFOLU (including FOLU)	23 343.8	5.2%	14 088.0	3.2%	-9 255.8	-39.6%
Waste	18 241.2	3.9 – 4.1%	23 045.8	4.9 – 5.2%	4 804.6	26.3%

[4] 1 giga tonne (Gt) = 1 000 mega tonne (Mt) = 1 000 000 giga gram (Gg) = 1 000 000 kilo tonne (kt)

[5] FOLU is defined by the United Nations Climate Change Secretariat as a "greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities."

Sector	2000 Emissions Inventory		2020 Emissions Inventory		Change kt CO_2-e	% Change 2000 to 2020
	GHG [kt CO_2-e]	% Contribution by Sector	GHG [kt CO_2-e]	% Contribution by Sector		
Total (excluding FOLU)	464 980.2	-	468 811.7	-	3 831.6	0.8%
Total (including FOLU)	445 884.9	-	442 125.1	-	-3 759.7	-0.8%

Notes: FOLU Forestry and Other Land Use

AFOLU Agriculture, Forestry and Other Land Use

IPPU Industrial Process and Product Use

1 giga tonne (Gt) = 1 000 mega tonne (Mt) = 1 000 000 giga gram (Gg) = 1 000 000 kilo tonne (kt)

The 2020 results revealed an increase in emissions in the energy (2.2%) and waste (26.3%) sectors relative to the year 2000. The decrease in the net AFOLU sector is due to an increasing land sink, in other words, more GHG was estimated to be absorbed by vegetation than previously calculated and is reflected as a slight increase of 0.8% from the 2000 total GHG emissions (excluding FOLU) of 464 980.2 kt CO_2-e and a reduction of 0.8% with the inclusion of FOLU, i.e., 445 884.9 kt CO_2-e for 2000.

The Energy sector is the largest contributor to South Africa's emissions (excl. FOLU), contributing 80% in 2020. According to the 2020 Report the Energy sector emissions increased between 2000 and 2009, then declined to 2014 after which total emissions were stable until 2019. Emissions declined by 6.8% between 2019 and 2020. This decline was due to Commercial/institutional emissions declining by 19.7%, along with a 13.7% reduction in Road transport and a 54.3% reduction in Civil aviation emissions. These reductions can be attributed to the reduced travel and trading during the COVID-19 lockdown restrictions.

6.4 GHG Emission Inventory for the Energy Sector

The DFFE published its Draft Methodological Guideline document on 19 February 2021 (*Government Gazette No. 44190*) with the updated and Final Methodological Guidelines for Quantification of GHG Emissions in October 2022 (DFFE, 2022) which describes the reporting methodology as specified in the NEM:AQA (Act No. 39 of 2004): National Greenhouse Gas Emission Reporting Regulations (NGERs) (South Africa, 2017). The current Project would be categorised in the "Energy" category for both the global GHG inventory and for the national GHG inventory.

According to the World Resources Institute Climate Watch[6], global GHG emissions from the Energy sector were 35 475.65 Mt CO_2-e in 2020. This contributes to 75% of total anthropogenic GHG emissions (including FOLU) of 47 513.15 Mt CO_2-e and 77% of total anthropogenic GHG emissions (excluding FOLU) of 46 120.92 Mt CO_2-e. According to the 2022 National GHG Inventory (DFFE, 2022), the South African Energy sector contributed 379.505 Mt CO_2-e to global Total GHG emissions in 2020, i.e., 0.82% and 0.8% to the global Total excluding and including FOLU, respectively; and 1.1% to the global Energy sector emissions.

CH_4 emissions, albeit of less concern in the current assessment since it is only emitted as part of fuel combustion, have a significant GWP, and it is prudent to include a short discussion on the contribution of fossil fuel to the global CH_4 budget. Estimates of CH_4 emissions are subject to a high degree of uncertainty, but the most recent comprehensive data in the *Global Methane Budget* (Global Methane Budget 2000-2017 (2020)) suggest that annual global methane emissions are around 592 Mt CO_2-e (572 – 614 Mt CO_2-e). This includes emissions from natural sources (around 40% of emissions) and those originating from human activity (the remaining 61%). The largest source groups of anthropogenic CH_4 emissions are agriculture and waste, responsible for 38% of the total, followed closely by the energy sector (23%), which includes emissions

[6] http://cait.wri.org/ and https://www.climatewatchdata.org

from coal, oil, natural gas and bioenergy. Natural sources include wetlands (largest natural global CH_4 source), geological, termites and the oceans. Oil and gas operations are likely the largest source of CH_4 emissions from the energy sector due to fugitive emissions from vents, leaks and unit operations, and not from routine emissions.

6.5 GHG Monitoring and Reporting

The NEM:AQA also provides for the monitoring and reporting of GHG emissions. The National Greenhouse Gas Emission Reporting Regulations (South Africa, 2017) were published in terms of Section 53 (aA), (o) and (p) of NEM: AQA on 3 April 2017 and amended on 11 September 2020 (South Africa, 2020). The purpose of these Regulations is to implement a single national reporting system for the transparent reporting of GHG emissions.

Exploration is included under IPCC Code 1.B.2 applicable for oil and natural gas operations as provided in *Annexure 1* of the amended Regulations. This source category activity specifically addresses fugitive emissions associated with well drilling, testing and servicing. As the threshold for this IPCC source category in the table is reflected as none, it means that the data provider has to report activity data and greenhouse gas emissions, irrespective of the size of greenhouse gas emissions and the scale of the operation of the activity.

Other activities may be associated with Code 1.A.3 *Transport*, with a set threshold of 100 000 litres per year fuel usage applicable to *Civil Aviation* (1.A.3.a) and *Water-borne Navigation* (1.A.3.d). Therefore, if the fuel usage is above this threshold, then the Regulations require that CO_2 and CH_4 levels (calculated based on Tier 2 or 3 methodologies) be reported annually via the South African Greenhouse Gas Emissions Reporting System (SAGERS). The system forms part of the national atmospheric emission inventory component of South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP).

The **South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions** only. For information, the three broad scopes for estimating GHG are:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, as well as the emissions of the users of the products produced by a company, and indirect GHG emissions from other source.

The DFFE is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the IPCC default emission figures may be used to populate the SAAELIP GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Technical guidelines for GHG emission estimation have been issued.

Also, the Carbon Tax Act (South Africa, 2019) includes details on the imposition of a tax on the carbon dioxide equivalent (CO_2-e)[7] of GHG emissions. According to this Act, a carbon taxpayer is a person who undertakes a taxable activity listed in Schedule 2 of the Carbon Tax Act in respect of which:

(i) it has an aggregated installed capacity equal to or above the tax threshold; or
(ii) a tax threshold indicated as 'none' applies[8]

[7] A CO_2 equivalent, abbreviated as *CO_2-e* is a metric measure used to compare the emissions from various GHGs on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of CO_2 with the same global warming potential.

[8] Footnote in the Amendments to the National Greenhouse Gas Emission Reporting Regulations (page 14 of Government Gazette No. 43712): *If the threshold for a specific IPCC source category in this table is reflected as none, it means that the data provider has to report activity data and greenhouse gas emissions, irrespective of the size of greenhouse gas emissions and the scale of the operation of the activity.*

In Schedule 2 of the Act, the proposed project is classified under 1.A.3 *Transportation* and the tax threshold column for *Civil Aviation* (1.A.3.a) and *Water-borne Navigation* (1.A.3.d) provides a threshold of 100 000 litres per year fuel usage for both activities, respectively, as well as no threshold for the oil and gas operations (1.B.2), which therefore implies a carbon tax return submission.

Certain production processes indicated in *Annexure A* of the Declaration of Greenhouse Gases as Priority Pollutants (South Africa, 2017) with GHG in excess of 0.1 Mega tonne (Mt), measured as CO_2-e, are required to submit a Pollution Prevention Plan (PPP) to the Minister for approval. The PPP regulations under Sections 29(3), 53 (o) and (p) read with section 57(1) (a) of the NEM:AQA, prescribe the requirements for the development and submission of PPPs.

The exploration is not anticipated to have emissions in excess of 0.1 Mt, thus, it may be concluded that the current project does not require a PPP.

6.6 Climate Change

The impacts of climate change as a result of, as well as potentially affecting the project is addressed by the environmental management tools of integrated environmental management (IEM) and EIA, as prescribed by the NEMA 107 of 1998. Given that the purpose of EIA is to give effect to the general objectives of IEM (section 24(1), NEMA), including sustainable development, there is a logical and necessary interrelationship between climate change and EIA.

NEMA sets out the general objectives of IEM in South Africa, including to (section 23(2)), of which the following two are of particular relevance in this report:

- Identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage, the risks and consequences and alternatives and options for mitigation of activities. This is to be done with a view to minimising negative impacts, maximising benefits and promoting compliance with the principles of environmental management set out in section 2 (of NEMA).
- Ensure that the effects of activities on the environment receive adequate consideration before actions are taken in connection with them.

7 METHODOLOGY

The approach to, and methodology followed in the completion of tasks as part of the scope of work are discussed.

7.1 GHG Emissions Inventory

As the emission of GHGs has a global impact, it is not feasible to follow the normal impact assessment methodology where the state of the physical environment after implementation of the project is compared to the condition of the physical environment prior to its implementation. Instead, this report will assess the following:

1. GHG emissions during operations compared to the global and South African emission inventories;
2. Impact of climate change over the lifetime of the Project taking the robustness of the project (i.e., would climate change have any impact on the project?) into account; and
3. Vulnerability of communities in the immediate vicinity of survey vessels (i.e., fishing activities and coastal human settlements) to climate change.

The Carbon Footprint is an indication of the GHGs estimated to be emitted directly and/or indirectly by an organisation, facility or product. It can be estimated from:

$$Carbon\ emissions = Activity\ data * emission\ factor * GWP$$

where

- *Activity data,* relates to the activity that causes the emissions[9]
- *Emission factor* refers to the amount of GHG emitted per unit of activity (unit of activity could typically be a mass or volume flow or consumed energy)[10]
- *GWP* - the Methodological Guidelines for Quantifying of GHG Emissions (DFFE, 2022) state that the following:
    - CH_4 emissions should have a multiplier of 23; and
    - N_2O emissions should have a multiplier of 296 (SA Technical Guidelines for Monitoring, Reporting and Verification of GHG Emissions (MG-2022,1 October 2022 Annexure H (DFFE, 2022))

GHG emissions will be released from the use of marine gas oil (MGO) in the support vessels and the drillship. In addition, the operation of a helicopter requires the use of kerosene. GHG fugitive emissions will be released from well drilling, testing and servicing. These activities are all considered to be **Scope 1** emissions. As per the National Greenhouse Gas Emission Reporting Regulations and the Methodological Guidelines for Quantifying of GHG Emissions, the IPCC default emission factors were used together with country-specific density and calorific values.

7.2 Projected and historic weather data

Potential future climate change effects and projections as included in the IPCC climate change assessment reports are estimated using climate models. As with all models there is the possibility of inaccuracies in the results associated with the model's physics and accuracy of input data. For this reason, an ensemble of several climate model results is employed to provide the basis for the results reported in the progressive IPCC assessment reports. Model ensembles have been completed since 1995 and these form part of a continued collaborative framework designed to improve knowledge of climate change,

[9] Defined in the Methodological Guidelines for Quantifying of GHG Emissions (DFFE 2022), as data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on energy use, metal production, land areas, management systems, lime and fertiliser use and waste arising are examples of activity data

[10] The Carbon Tax Regulation definition for "emission factor" means the average emission rate of a given GHG for a given source, relative to the activity data of a source stream assuming complete oxidation for combustion and complete conversion for all other chemical reactions.

known as the *Coupled Model Intercomparison Project* (CMIP). The CMIP was organized by the Working Group on Coupled Modelling (WGCM) of the World Climate Research Programme (WCRP). It has been developed in phases to foster the climate model improvements but also to support the IPCC climate change assessment reports. Whilst the AR6 (based on the CMIP Phase 6 model results) is the most recent, several studies have been completed using the results from the IPCC AR5, which was based on the CMIP Phase 5 model results.

The GreenBook supports government in South Africa with adapting settlements to the impacts of climate change by providing an online repository of downscaled, baseline and future, municipal climate risk data and insights as well as adaptation information to be integrated into broader settlement planning. The GreenBook is an online planning support tool that provides quantitative scientific evidence on the likely impacts that climate change and urbanisation will have on South Africa's cities and towns, as well as presenting a number of adaptation actions that can be implemented by local government to support climate resilient development. The GreenBook was co-funded by the Council for Scientific and Industrial Research (CSIR) and the International Development Research Centre (IDRC), between 2016 and 2019.

The South African Weather Services (SAWS) further embarked on more detailed ("downscaled") modelling and produced the Climate Change Reference Atlas (CCRA) using as basis CMIP Phase 5 in an effort to improve the spatial resolution over South Africa.

In addition to the above SAWS study, the Western Cape Climate Change Response Framework and Implementation Plan for the Agricultural Sector (SmartAgri; ACDI, 2016) made use of a climate change science study conducted in the years 2014-2015, and subsequently updated in 2022. The study made use of the 23 "SmartAgri zones" that capture the climatic gradients, complex topography, oceanic influences, soils and farming systems across the province in specific areas. The approach taken to climate change projections in the analysis was based on the results derived from CMIP Phase 5, CMIP Phase 6 and the Coordinated Regional Downscaling Experiment (CORDEX, Giorgi et al., 2009)[11].

[11] CORDEX is a globally coordinated project with the objective of dynamically (and statistically) downscaling the CMIP5 model ensembles, as well as further develop regional downscaling. CORDEX Africa developed dynamical downscaling of CMIP5 across the entire African continent at a grid resolution of around 0.44° horizontally (45-50km). CORDEX Africa has been extensively analysed and used to develop climate impacts assessments across all regions of Africa.

8 RECEIVING ENVIRONMENT

The inclusion of climate change considerations into the mitigation context might mean providing recommendations for the reduction of GHG emissions associated with the proposed project, whereas adaptation, on the other hand, might lead to recommendations on how to modify the project considering potential climate change impacts. In this respect, it is necessary to understand future projections of weather conditions, typically including changes in rainfall patterns, ambient temperature variations, sea rise, etc.

Summaries of the temperature and rainfall projections provided in the various studies, namely the CSIR Greenbook, the CCRA (downscaled from AR5), the AR6, and SmartAgr, are provided in the sections below.

8.1 Historic Temperature and Rainfall

The average historic temperature (depicted in degrees Celsius) and average rainfall (depicted in millimetres) for the Saldanha Bay, Bergrivier, Cederberg and Matzikama Municipalities are shown in Figure 8-1 to Figure 8-4 (1961-1990).

All the municipalities show rainfall of less than 400 mm per year, and average temperatures along the coast of between 16 and 18 °C.

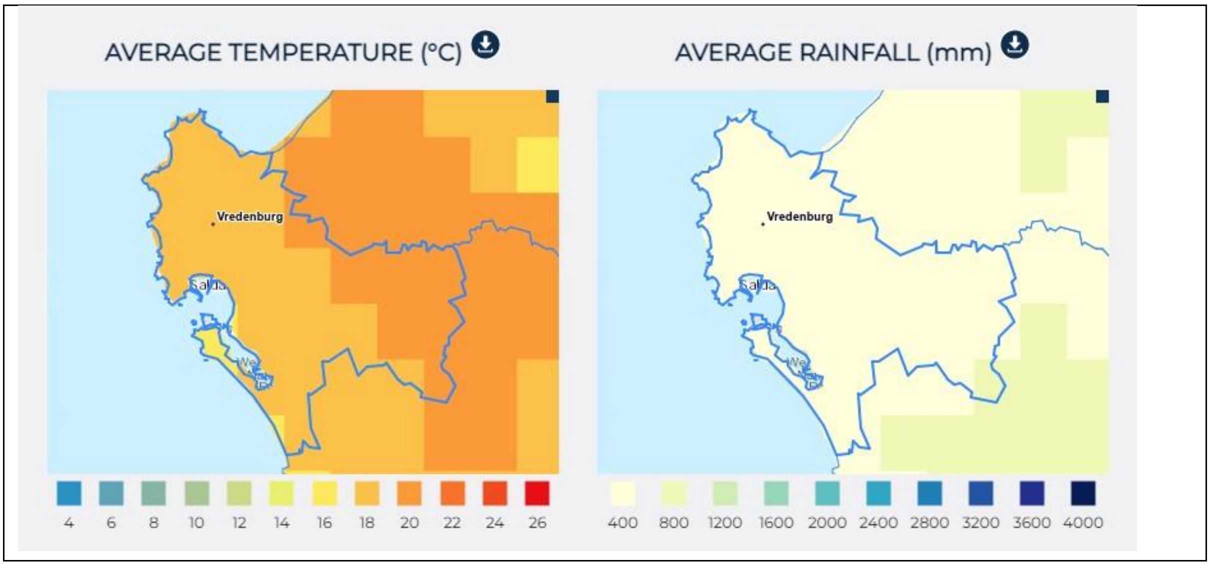


Figure 8-1: Average temperature and rainfall for Saldanha Bay Municipality (https://riskprofiles.greenbook.co.za/)

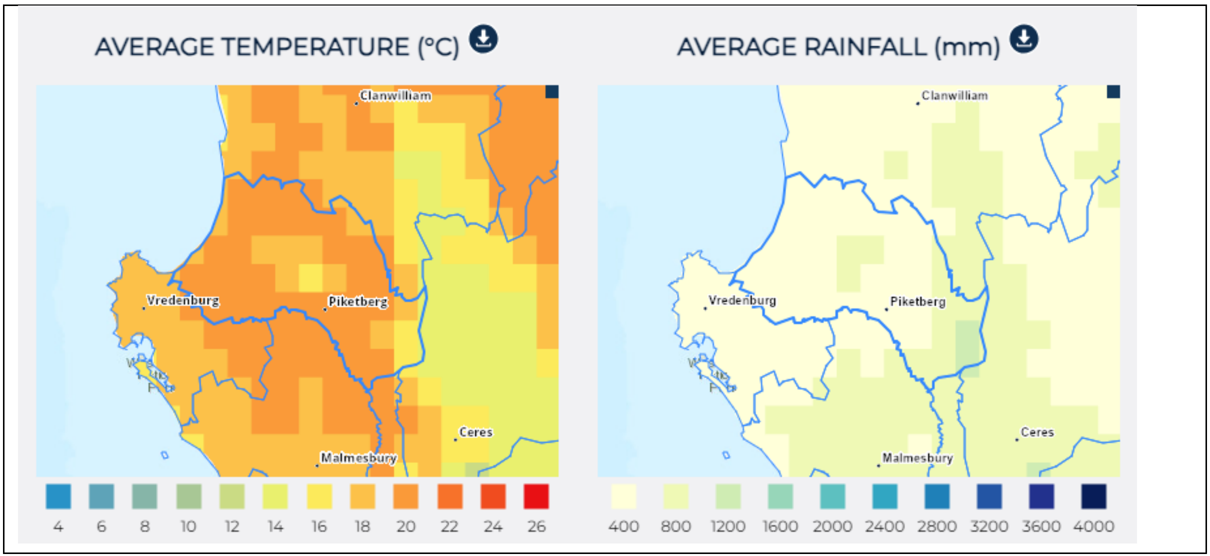


Figure 8-2: Average temperature and rainfall for Bergrivier Municipality (https://riskprofiles.greenbook.co.za/)

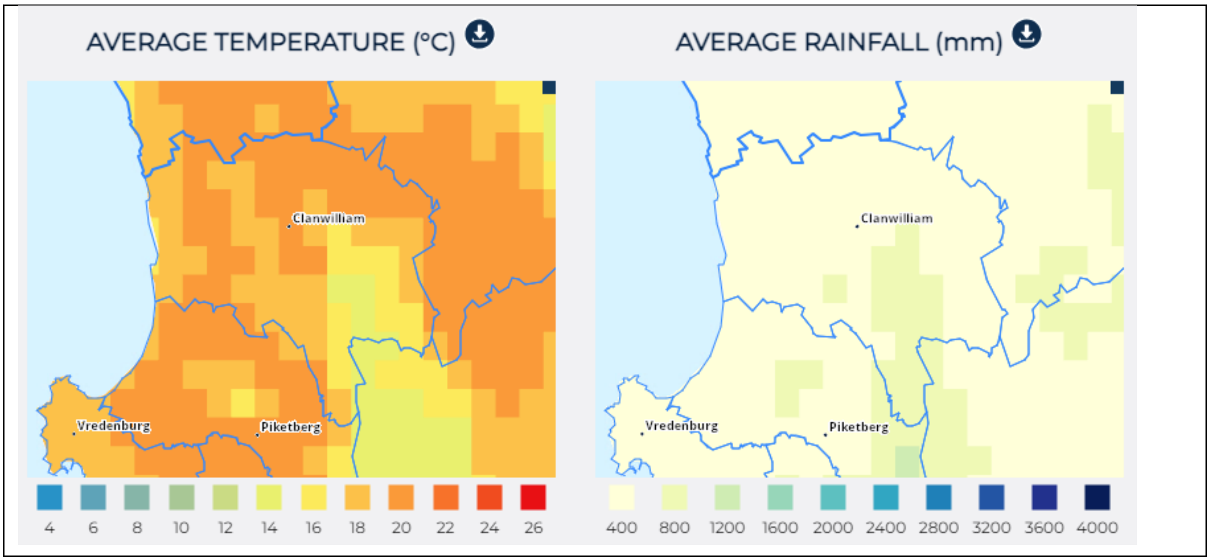


Figure 8-3: Average temperature and rainfall for Cederberg Municipality (https://riskprofiles.greenbook.co.za/)

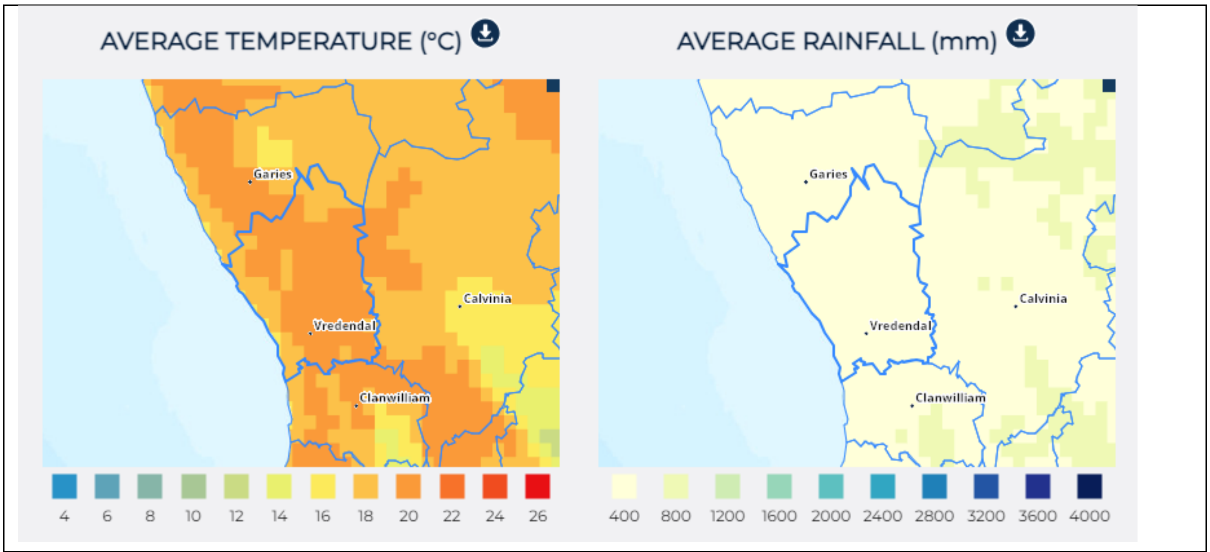


Figure 8-4: Average temperature and rainfall for Matzikama Municipality (https://riskprofiles.greenbook.co.za/)

8.2 Temperature and Rainfall Projections: CSIR Greenbook

Climate change metrics for projected change in temperature (Figure 8-5); rainfall (Figure 8-6); extreme rainfall events (Figure 8-7) and very hot days (Figure 8-8) are shown below. The projected change for the period 2021-2050, relative to the baseline period (1961-1990) is indicated. A vey hot day is a day when the maximum temperature exceeds 35 °C. An extreme rainfall event is defined as 20 mm of rain occurring within 24 hours.

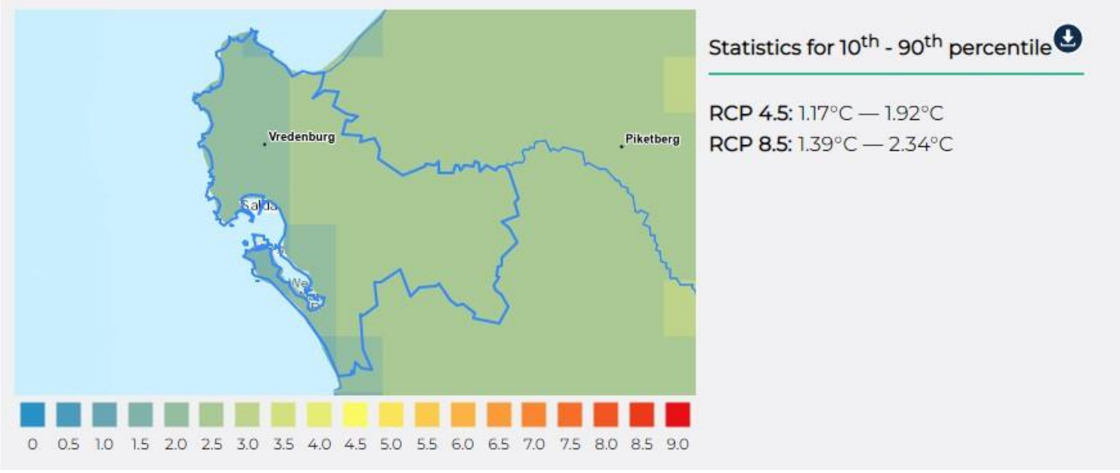


Figure 8-5: Projected change in temperature (https://riskprofiles.greenbook.co.za/)

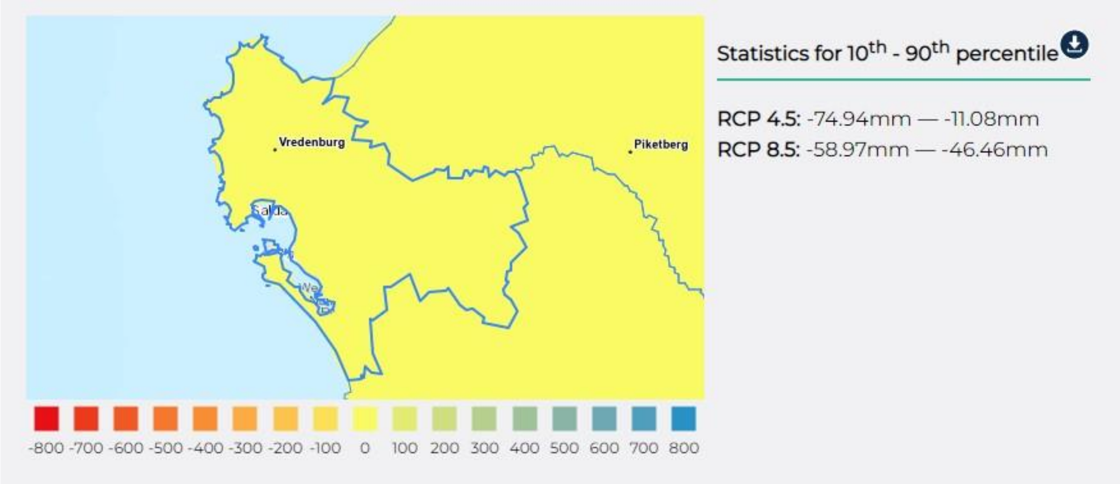


Figure 8-6: Projected change in rainfall (https://riskprofiles.greenbook.co.za/)

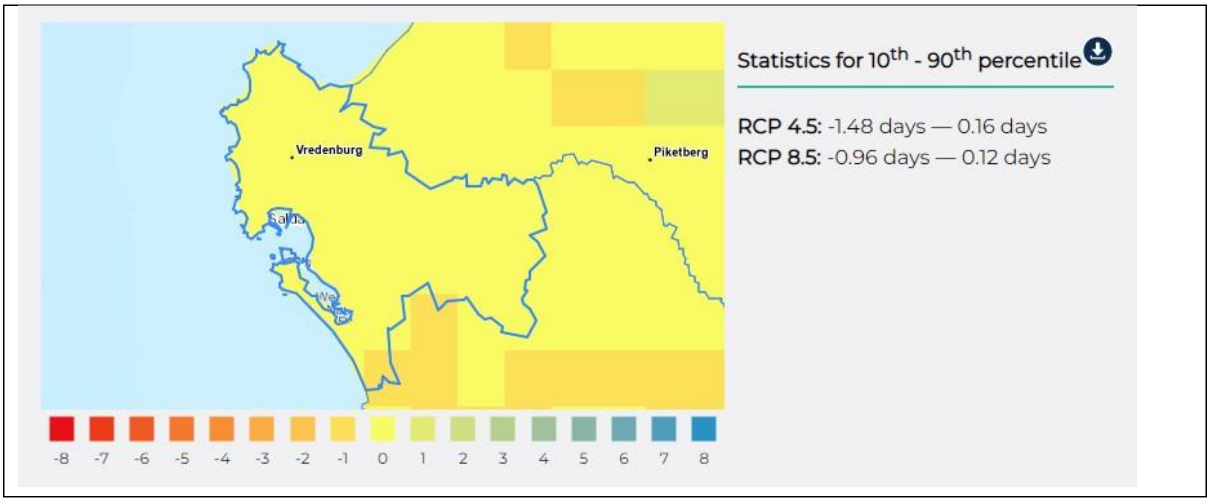


Figure 8-7: Projected change in extreme rainfall days (https://riskprofiles.greenbook.co.za/)

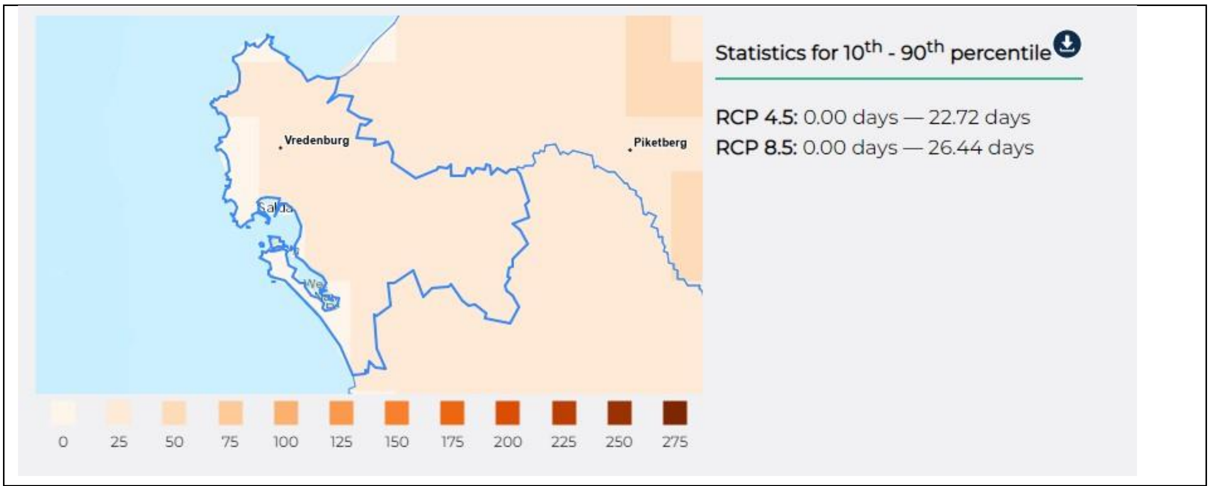


Figure 8-8: Projected change in very hot days (https://riskprofiles.greenbook.co.za/)

8.3 Temperature and Rainfall Projections: SAWS CCRA

The SAWS study based its climate change scenarios on the seven Representative Concentration Pathways (RCPs) as discussed in AR5 (IPCC, 2013) with a summarised version in Appendix A. This section summarises the projections for the two most referenced RCPs, i.e.,

- RCP4.5 – described by the IPCC in AR5 as an "intermediate" pathway[12]" and is based on the assumption that current interventions to reduce GHG emissions are sustained (after 2100 the concentration is expected to stabilise or even decrease) and is likely to result in global temperature rise between 1.1°C and 2.6°C, by 2100. The emission scenarios are biased towards exaggerated availability of fossil fuels reserves and is considered to be the most probable baseline scenario taking into account the exhaustible character of non-renewable fuels.
- RCP8.5 – representing the worst-case pathway, based on the assumption that no interventions to reduce GHG emissions are implemented (after 2100 the concentration is expected to continue to increase) and is likely than to result in global temperature rise between 2.6°C and 4.8°C, by 2100.

[12] RCP4.5 represents a pathway between RCP 3.4 (2.0°C to 2.4°C warming by 2100) and RCP8.5 (no mitigation interventions and (2.6°C to 4.8°C warming by 2100).

RCP4.5 Projection

Based on the median, for the west coast region in which the Project is situated, **the annual average near surface temperatures (2 m above sea surface) are expected to increase by between 1.0°C and 1.5°C for the near future (2036 to 2065) and between 1.0°C and 2.0°C for the far future (2066 to 2095)**. The seasonal average temperatures are expected to increase for all seasons, in the same order as the annual average increases with slightly lower increases in autumn (March to May) and winter (June to August), as summarised in Table 8-1.

Table 8-1: Projected increase in seasonal temperature in the project region in RCP4.5

Season	Near future (2036-2065)	Far future (2066-2095)
Summer (December to February)	1.0°C to 1.5°C	1.0°C to 2.0°C
Autumn (March to May)	1.0°C to 1.5°C	1.0°C to 1.5°C
Winter (June to August)	1.0°C to 1.5°C	1.0°C to 1.5°C
Spring (September to November)	0.5°C to 1.5°C	1.0°C to 2.0°C

The **total annual rainfall over the region is expected to decrease by between 0 mm and 20 mm (Cape Town), between 0 mm and 10 mm (Saldanha Bay) and between 0 mm and 5 mm (Port Nolloth) for the near and far future**. Predicted reduction in seasonal rainfall is shown in Table 8-2, indicating the same rainfall reduction for near and far future scenarios except for the coast off Cape Town with a projected higher reduction for winter.

Table 8-2: Projected reduction in seasonal rainfall in the project region in RCP4.5

Season	Location	Near future (2036-2065)	Far future (2066-2095)
Summer (December to February)	Port Nolloth	0 mm to 5 mm	0 mm to 5 mm
	Saldanha Bay	0 mm to 5 mm	0 mm to 5 mm
	Cape Town	0 mm to 5 mm	0 mm to 5 mm
Autumn (March to May)	Port Nolloth	0 mm to 5 mm	0 mm to 5 mm
	Saldanha Bay	5 mm to 10 mm	5 mm to 10 mm
	Cape Town	10 mm to 20 mm	10 mm to 20 mm
Winter (June to August)	Port Nolloth	0 mm and 5 mm	0 mm and 5 mm
	Saldanha Bay	5 mm to 10 mm	5 mm to 10 mm
	Cape Town	0 mm to 5 mm	5 mm to 20 mm
Spring (September to November)	Port Nolloth	0 mm to 5 mm	0 mm to 5 mm
	Saldanha Bay	5 mm to 10 mm	5 mm to 10 mm
	Cape Town	10 mm to 20 mm	10 mm to 20 mm

RCP8.5 Projection

Based on the median, the region in which the Project is situated, the annual average near surface temperatures (2 m above the surface) are projected to increase by between 1.5°C and 2.0°C for the near future (2036 to 2065) and between 2.0°C and 3.0°C for the far future (Table 8-3). The seasonal annual rainfall projections are summarised in Table 8-4.

Table 8-3: Projected increase in seasonal temperature in the project region in RCP8.5

Season	Near future (2036-2065)	Far future (2066-2095)
Summer (December to February)	1.0°C to 2.0°C	2.0°C to 3.0°C
Autumn (March to May)	1.0°C to 2.0°C	2.0°C to 3.0°C
Winter (June to August)	1.0°C to 1.5°C	2.0°C to 3.0°C
Spring (September to November)	1.0°C to 1.5°C	2.0°C to 3.0°C

Table 8-4: Projected reduction in seasonal rainfall in the project region in RCP8.5

Season	Location	Near future (2036-2065)	Far future (2066-2095)
Summer (December to February)	Port Nolloth	0 mm to 5 mm	0 mm to 5 mm
	Saldanha Bay	0 mm to 5 mm	0 mm to 5 mm
	Cape Town	5 mm to 10 mm	5 mm to 10 mm
Autumn (March to May)	Port Nolloth	0 mm to 5 mm	0 mm to 10 mm
	Saldanha Bay	5 mm to 10 mm	10 mm to 20 mm
	Cape Town	5 mm to 10 mm	20 mm to 30 mm
Winter (June to August)	Port Nolloth	0 mm and 10 mm	5 mm and 20 mm
	Saldanha Bay	10 mm to 20 mm	10 mm to 50 mm
	Cape Town	5 mm to 20 mm	10 mm to 50 mm
Spring (September to November)	Port Nolloth	0 mm to 10 mm	0 mm to 5 mm
	Saldanha Bay	10 mm to 20 mm	10 mm to 20 mm
	Cape Town	10 mm to 20 mm	20 mm to 30 mm

8.4 Temperature and Rainfall Projections: AR6

AR6 based its climate change on the five Shared Socioeconomic Pathway (SSP) scenarios as discussed in AR6 (IPCC 2022a) with a summarised version in Appendix D. To compare with the CCRA projections the following two scenarios apply:

- SSP2-4.5 is a "middle of the road" scenario. CO_2 emissions hover around current levels before starting to fall mid-century, but do not reach net-zero by 2100. Socioeconomic factors follow their historic trends, with no notable shifts. Progress toward sustainability is slow, with development and income growing unevenly. In this scenario, temperatures rise 2.7°C by the end of the century.
- SSP5-8.5 is a future to "avoid at all costs". Current CO_2 emissions levels roughly double by 2050. The global economy grows quickly, but this growth is fuelled by exploiting fossil fuels and energy-intensive lifestyles. By 2100, the average global temperature is a scorching 4.4°C higher.

The AR6 projections for the study area for the "middle of the road" scenario (SSP2-4.5) indicate an increase in annual average temperatures from +1.4°C for the period 2041 to 2060, to +2.2°C for the period 2081 to 2100. The projections for the "avoid at all cost"-scenario (SSP5-8.5) indicate an increase in annual average temperatures from +1.8°C for the period 2041 to 2060 (defined in AR6 as "mid-term"), to +4.2°C for the period 2081 to 2100 (defined in AR6 as "long-term"). Although the CCRA and AR6 projections are based on different baselines, with the former earlier by a decade, and the definitions of the scenarios not exactly the same, the temperature projections are similar, as shown in Table 8-5.

Table 8-5: Comparison of projected increase in annual average temperature in the project region

Study/Report	Base Period	Scenario	Near future/Mid-Term[(a)]	Far future/Long-Term[(b)]
CCRA (SAWS downscaled simulations)	1975-2005	RCP4.5	1.0°C to 1.5°C	1.0°C to 2.0°C
		RCP8.5	1.5°C to 2.0°C	2.0°C to 3.0°C
AR6 (Climate Knowledge Portal CMIP6)	1995-2014	SSP2-4.5	1.2°C	1.83°C
		SSP5-8.5	1.83°C	3.69°C

Notes: [(a)] CCRA: *Near Future* 2036-2065 and AR6: *Mid-Term* 2041-2060

[(b)] CCRA: *Far Future* 2066-2095 and AR6 *Long-Term* 2081-2100

[(c)] https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-projections

The AR6 projections for rainfall in the study area for SSP2-4.5 indicate a decrease in annual rainfall of 25 mm for the period 2041 to 2060, to 37 mm for the period 2081 to 2100. The projections for SSP5-8.5 indicate decrease of 32 mm for the period 2041 to 2060, to 80 mm for the period 2081 to 2100, as shown in the comparison in Table 8-6.

Table 8-6: Comparison of projected total annual rainfall reductions in the project region

Study/Report	Base Period	Scenario	Near future/Mid-Term[(a)]	Far future/Long-Term[(b)]
CCRA (SAWS downscaled simulations)	1975-2005	RCP4.5	0 mm (Port Nolloth) to 20 mm (Cape Town)	0 mm (Port Nolloth) to 50 mm (Cape Town)
		RCP8.5	10 mm (Port Nolloth) to 70 mm (Cape Town)	20 mm (Port Nolloth) to 100 mm (Cape Town)
AR6 (Climate Knowledge Portal CMIP6)	1995-2014	SSP2-4.5	25 mm	37 mm
		SSP5-8.5	32 mm	80 mm

Notes: [(a)] CCRA: *Near Future* 2036-2065 and AR6: *Mid-Term* 2041-2060

[(b)] CCRA: *Far Future* 2066-2095 and AR6 *Long-Term* 2081-2100

[(c)] https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-projections

8.5 Temperature and Rainfall Projections: SmartAgri Report

The SmartAgri Report concludes that as a whole, **the region has experienced significant increases in temperature across all zones and all seasons over the past century**, with more rapid warming over the past 30 years. While the report acknowledges that some uncertainty and complexity remain, especially with regard to changes in rainfall, the region encompasses a number of somewhat independent climatic conditions. Future projected changes in rainfall indices[13] show some variation across the province so that, while reductions in rainfall are strongly dominant, it is possible that different patterns of change may unfold. Different dynamics are involved in producing changes in summer rainfall over the northern/eastern parts of the province versus the southern regions and the western regions. The clear message is that **reductions in rainfall should be anticipated across the region, but some subregions may experience much stronger reductions than other subregions.** Albeit the uncertainty around projected changes in rainfall, the analysis of projected changes in water balance and potential evapotranspiration is clear due to the projected increases in temperature, involving very little uncertainty. The report found that the projected changes for the regions derived from CMIP6 do not vary significantly to those derived from CMIP5 over the southern African region, though CMIP6 on average projects stronger temperature increases globally and there are some differences in regional patterns of rainfall change.

8.6 Sea Level Rise: AR6

Figure 8-9 illustrates the latest projected sea level rise under different SSP scenarios as reported in AR6 (IPCC, 2021) for two locations along the west coast, namely Port Nolloth in the north and Granger Bay in the south. Projections are relative to a 1995-2014 baseline and summarised in Table 8-7 for the mid-term (2041 to 2060) and long-term (2081 to 2100) periods. The projections for the sea level rise at Port Nolloth for SSP2-4.5 indicate an increase of 0.29 m for the mid-term to 0.60 m for the long-term. The projections for SSP5-8.5 indicate an increase of 0.34 m for the mid-term to 0.82 m for the long-term. The sea level rise at Granger Bay (Cape Town) for SSP2-4.5 indicate an increase of 0.26 m for the mid-term to 0.55 m for the long-term. The projections for SSP5-8.5 indicate an increase of 0.31 m for the mid-term to 0.77 m for the long-term.

Table 8-7: Projected increase in mean sea level in the project region

Study/Report	Site	Scenario	Mid-term (2041-2060)	Long-Term (2081-2100)
AR6	Port Nolloth	SSP2-4.5	0.29 m	0.60 m
		SSP5-8.5	0.34 m	0.82 m
AR6	Granger Bay	SSP2-4.5	0.26 m	0.55 m
		SSP5-8.5	0.31 m	0.77 m

[13] A suite of standard climate indices has been calculated for both historical observations (mean conditions and trends) as well as future projections. These indices are largely based on the widely adopted indices of the Expert Team for Climate Change Detection. Monitoring and Indices (ETCCDMI) as documented: http://etccdi.pacificclimate.org/list_27_indices.shtml.

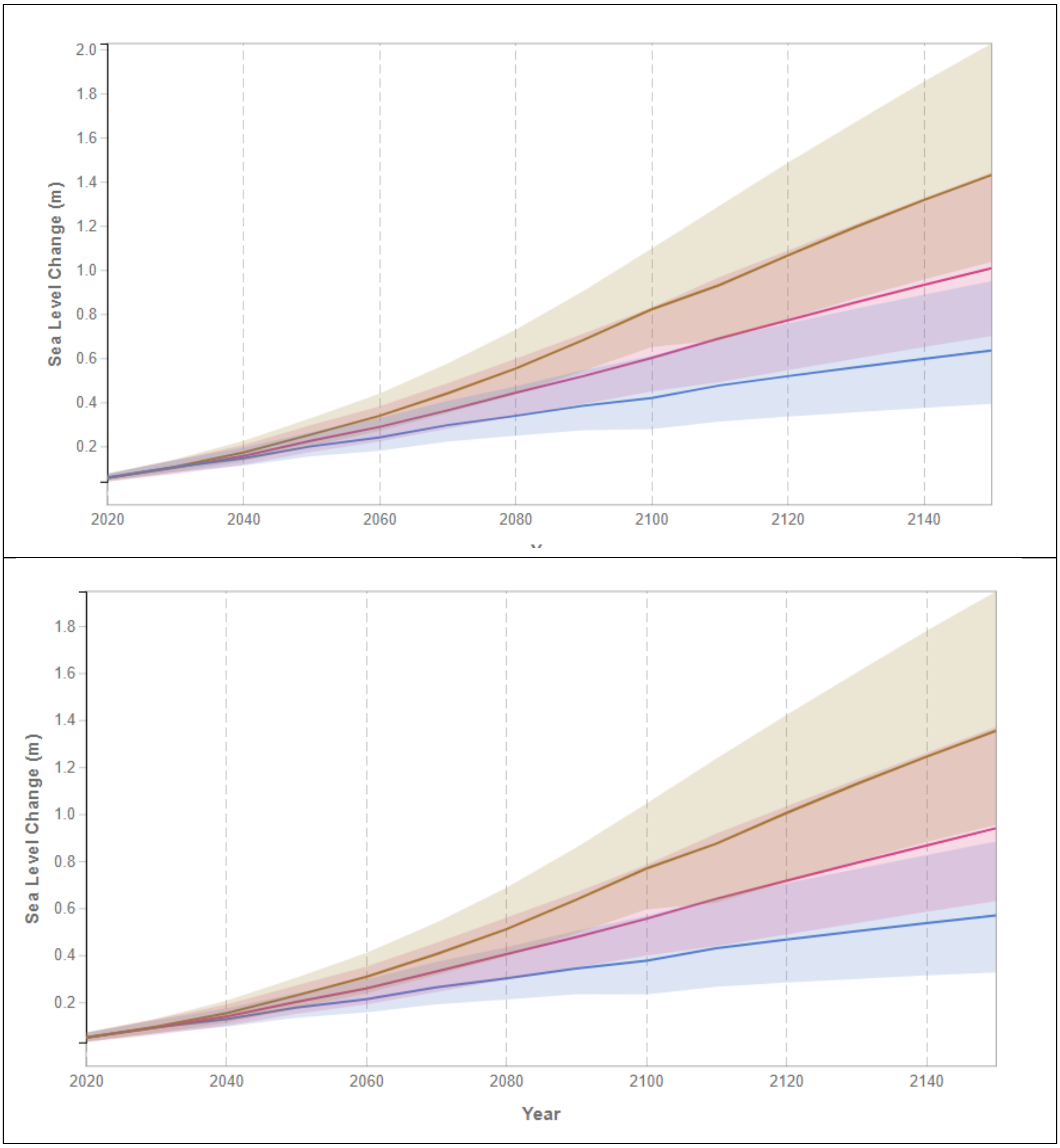
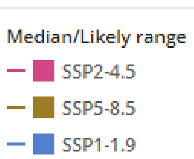


Figure 8-9: Sea level projections for Port Nolloth and Granger Bay (Cape Town) as per the AR6 results (IPCC – Sea Level Projection Tool hosted by NASA: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool)



8.7 Rare and Extreme Events

(Musekiwa, Cwthra, Unterner, & van Zyl, 2015) synthesised existing literature on coastal vulnerability both from South Africa and from international studies and communications with experts to determine the parameters relevant for the classification of coastal vulnerability. The Coastline Vulnerability Index (CVI) ranges from 1 (very low) to 5 (very high). The CVI was based on ten physical coastal parameters, including elevation, beach width, tidal range, maximum wave height, geology (magmatic, metamorphic sedimentary and unconsolidated sediments), anthropogenic activities (with or without stabilisation intervention), distance to 20 m isobaths[14], relative sea-level change, mean wave height and beach geomorphology. The study concluded with the CVIs ranging predominantly 3, south of Koingnass to Cape Town, with some coastline areas reporting as 1 and 5. North of Koingnaas, the CVI2 are mostly 1 and 5, with occasional areas between these two extremes.

According to Theron (2011), cited in Davis-Reddy and Vincent (2017), **coastal residents may be more affected by the increased occurrence or intensity of storms than by relatively slow shoreline migration as result of sea level rise.** The most noticeable effects will mostly be in the form of higher tidal regimes and increased wind speeds associated with storm surges.

Extreme weather events affecting southern Africa, including heat waves, flooding due to intensified rainfall due to large storms, and drought, have been shown to increase in number since 1980 (Davis-Reddy & Vincent, 2017). Projections indicate (Davis-Reddy and Vincent 2017):

- With *high confidence:* heat wave and warm spell durations are likely to increase, while cold extremes are likely to decrease. Up to 80 days above 35°C are projected by the end of the century under the AR6 RCP4.5 scenario; and
- With *medium confidence*: droughts are likely to intensify due to reduced rainfall and/or an increase in evapotranspiration.

Tropical cyclones are generated in areas where the ocean surface temperature is greater than 27°C and between latitudes 5°S to 30°S. Since the Area of Interest is located in an area where the ocean surface temperature is colder than 27°C, and south of 34°-degree latitude it is therefore not subject to tropical cyclones.

[14] Defined as the contour beyond which sea depth is >20m.

9 IMPACT ON THE RECEIVING ENVIRONMENT

9.1 GHG Emissions

Sources of emission and associated pollutants considered in the emissions inventory included:

- Combustion emissions
- Waste gas/oil disposal emissions
- Process emissions

All emissions were determined through the application of emission factors either from the South African Methodological Guidelines for the Quantification of Greenhouse Gas Emissions or the IPCC Guidelines for National Greenhouse Gas Inventories. A summary of sources quantified, emissions estimation techniques applied, emission factors and source input parameters are summarised in Table 9-1. Estimated annual average emissions, per source group, are presented in Table 9-2.

Table 9-1: Emission estimation techniques and parameters

Source Group	Emission Estimation Technique Emissions factors	Input Parameters
Combustion	Methodological Guidelines for Quantification of Greenhouse Gas Emissions (Version No: MG-2022.1) (Table A.3 Country specific CO_2 EF) CO_2: 73 090 kg/TJ Volume 2, Chapter 3 Mobile Combustion (Table 3.5.3 Water-borne navigation) CH_4: 7 kg/TJ N_2O: 2 kg/TJ	Drill rig: 65 days/exploration period, 22 000 litres/day – 1 430 000 litres/exploration period Platform service vessel (psv): 84 days/exploration period, 5 000 litres/day – 420 000 litres/exploration period Anchor handling tug (aht): 74 days/exploration period, 20 000 litres/day – 1 480 000 litres/exploration period Assumed a marine gas oil density of 0.84 kg/l (Table A.1, Life Cycle Assessment of Greenhouse Gas and Criteria Air Pollutant Emissions from Conventional and Biobased Marine Fuels)
Combustion	Methodological Guidelines for Quantification of Greenhouse Gas Emissions (Version No: MG-2022.1) (Table A.3 Country specific CO_2 EF) CO_2: 73 463 kg/TJ Volume 2, Chapter 3 Mobile Combustion (Table 3.6.5 Civil Aviation) CH_4: 0.5 kg/TJ N_2O: 2 kg/TJ	Helicopter: 16 176 nautical miles (NM)/exploration period, 3.75 litres/NM – 82 500 litres/exploration period Assumed average value for the various countries. Assumed a jet kerosene density of 0.794 kg/l (Table D.1, SA Technical guidelines)
Waste gas/oil disposal	Volume 2, Chapter 2 Stationary Combustion (Table 2.3 Stationary combustion crude oil) CO_2: 73 300 kg/TJ CH_4: 3 kg/TJ N_2O: 0.6 kg/TJ	Burning of oil: range of between 100 to 1000 bbl per day Assumed 10 days per exploration period Assumed a crude oil density of 873.46 kg/m³ (Table 3-8, Compendium of GHG Methodologies for the Natural Gas and Oil Industry 2021)
Waste gas/oil disposal	Volume 2, Chapter 4 Fugitive Emissions	Flaring of gas: 30 MMscfd Assumed 10 days per exploration period

Source Group	Emission Estimation Technique Emissions factors	Input Parameters
	(Table 4.2.5 EF Fugitive emissions from oil and gas operations in developing countries – see note e) CO_2: 2 Gg/10^6 m³ gas flared CH_4: 0.012 Gg/10^6 m³ gas flared N_2O: 0.000023 Gg/10^6 m³ gas flared	Assumed a natural gas density of 0.6728 kg/m³ (Table 3-8, Compendium of GHG Methodologies for the Natural Gas and Oil Industry 2021)
Process	Volume 2, Chapter 4 Fugitive Emissions (Table 4.2.5 EF Fugitive emissions from oil and gas operations in developing countries – well drilling) CO_2: 1.7E-3 to 1E-4 Gg/10^3 m³ total oil production CH_4: 5.6E-4 to 3.3E-5 Gg/10^3 m³ total oil production Volume 2, Chapter 4 Fugitive Emissions (Table 4.2.5 EF Fugitive emissions from oil and gas operations in developing countries – well testing) CO_2: 1.5E-1 to 9E-3 Gg/10^3 m³ total oil production CH_4: 8.5E-4 to 5.1E-5 Gg/10^3 m³ total oil production N_2O: 1.1E-6 to 6.8E-8 Gg/10^3 m³ total oil production Volume 2, Chapter 4 Fugitive Emissions (Table 4.2.5 EF Fugitive emissions from oil and gas operations in developing countries – well servicing) CO_2: 3.2E-5 to 1.9E-6 Gg/10^3 m³ total oil production CH_4: 1.8E-3 to 1.1E-4 Gg/10^3 m³ total oil production	Oil: range of between 100 to 1000 bbl per day Assumed 84 days per exploration period

Table 9-2: Estimated annual average GHG emission rates

Source Group	CO_{2e} (kt per annum) – lower range	CO_{2e} (kt per annum) – upper range
Combustion – psv and aht	4.761	4.761
Combustion – drill rig	3.583	3.583
Combustion - helicopter	0.214	0.214
Waste gas disposal – gas flaring	19.348	19.348
Waste gas disposal – oil burning	0.393	3.927
Process – well drilling	0.0001	0.002
Process – well testing	0.002	0.027
Process – well servicing	0.0004	0.007
Total Emissions	**28.302**	**31.870**

9.2 The Project's GHG contribution on the Sector and on the National Inventory

Based on the published 2020 National GHG annual Inventory for South Africa (Section 6.3, Table 6-2), **the maximum total CO_2-e emissions from the Project, assuming a maximum survey duration of 84 days, would contribute approximately 0.008% to the 2020 South African "energy" sector total of 379 505.2 kt CO_2-e, and represent a contribution of 0.007% to the 2020 National GHG inventory total of 468 811.7 kt CO_2-e (excluding FOLU).**

9.3 Alignment with National Policy

Most of the South African GHG policy is in early phases of implementation where GHG emissions have been reported to DFFE since 31 March 2018 and the Carbon Tax Act came into effect on the 1 June 2019. **The Project will be required to align GHG reporting with national policy. An annual Carbon Tax environmental levy will need to be submitted in July of each year after operations commence.**

9.4 Significance of Impact on the Environment

The methodology used for assessing the significance of the impact was obtained from EIMS. The environmental risk is dependent on the consequence and the probability that the impact will occur.

Step 1: Determine the CONSEQUENCE of the impact by using the factors below.

Some of the gaseous pollutants released from the drilling activity, project vessels and helicopter would contribute to global GHG emissions. The release of GHG includes mainly CO_2, CH_4 and N_2O. GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. The effect of climate change is related to changing atmospheric GHG concentrations, increased temperatures, changing weather patterns and sea level rise (indirect negative impact).

The calculated emissions (upper estimate) from the operations are estimated to be 31.87 kt CO_2-e.

The context within which reporting requirements were developed to describe and assess environmental impacts, have yet to be applied to GHG emissions. As part of the process to determine if a full GHG analysis and mitigate programme is required, in the Sacramento Metropolitan Air Quality Management District (California, USA), an *Initial Study* is implemented to determine if a project may have a significant effect on the environment. As such a threshold of 1.1 kt CO_2-e (project construction phase) and 10 kt CO_2-e (operational phase) for stationary source projects per year is applied to new projects (SMAQMD, 2014). These thresholds were based on capturing 90% of the development projects across the state, ensuring that small projects, which generally have low emission levels, and would generally not be considered significant.

As an alternative method of measure, a GHG threshold may be based on the classification of projects by the European Bank for Reconstruction and Development (EBRD), in which projects contributing more than 25 kt CO_2-e per year to have significant GHG emissions[15] (EBRD, 2019). This is in line with the International Finance Corporation (IFC, 2012). *Section 8* of the *IFC Performance Standards on Environmental and Social Sustainability*: "*For projects that are expected to or currently produce more than 25 000 tonnes of CO_2-equivalent annually the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary, as well as indirect emissions associated with the off-site production of energy used by the project. Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognised methodologies and good practice*".

[15] As per the EBRD's Environmental and Social Policy, projects leading to a relative emissions change (either increase or decrease) higher than 25 kt CO_2-e annually are subject to mandatory GHG assessment. The EBRD approach is available at: https://www.ebrd.com/documents/admin/ebrd-protocol-for-assessment-of-greenhouse-gas-emissions.pdf.

In terms of the *Equator Principles*, a developer that is seeking funding from a financial institution that subscribes to the Equator Principles is required to publicly report on its combined Scope 1 and Scope 2 GHG emissions if it exceeds 100 kt CO_2e annually, for the operational phase of the Project, during the life of the loan (Equator Principles, 2013). The Equator Principles also encourage clients to report publicly on projects emitting over 25 kt CO_2e, in line with the IFC Performance Standards (Equator Principles, 2013). As a further example, the South African Declaration of Greenhouse Gases as Priority Pollutants (*Government Gazette 40966 of 21 July 2017*) define production processes in *Annexure A* of the *Declaration* with the requirement to submit a PPP to the Minister for approval with GHG more than 100 kt CO_2-e.

When evaluating significance, all new GHG emissions contribute to a negative environmental impact; however, some projects could replace existing development or baseline activity that has a higher GHG profile. Therefore, the significance of a project's emissions should be based on its net impact over its lifetime, which may be positive, negative or negligible.

The proposed exploration project is temporary, but may lead to long-term operation, which further complicates the significance rating process. To meet the South African NDC targets and interim budgets, action is required to reduce GHG emissions from all sectors, including projects in the built and natural environment. The proposed Project must therefore consider whether and how the Project will contribute to or jeopardise the achievement of these targets. Such an assessment would however require a much broader evaluation of the Project against all current energy mix and their resources practiced in South Africa. In the absence of such a comprehensive assessment, the current assessment will rely on using thresholds to define the significance of the GHG impact. The proposed intensity rating is as follows:

25 kt CO_2-e	:	Very Low (i.e., threshold used by EBRD, IFC and Equator Principals)
25 – 100 kt CO_2-e	:	Low (i.e., DFFE PPP requirement threshold is 100 kt CO_2-e)
100 – 500 kt CO_2-e	:	Medium (i.e., DFFE PPP to 0.1% of the total gross RSA GHG emissions)
500 – 5 000 kt CO_2-e	:	High (i.e., 0.1% to 1.0% of the total gross RSA GHG emissions)
>5 000 kt CO_2-e	:	Very High (i.e., more than 1.0% of the total gross RSA GHG emissions)

The combined GHG emissions per annum of 31.87 kt CO_2-e are below the DFFE PPP reporting requirement threshold of 100 kt CO_2-e, and less than 0.1% of the total gross RSA GHG emissions, and therefore considered to have a **low intensity**. Given that the negative impact is of **low intensity**, **national extent, irreversible** (due to its limited period of emission and future uptake by vegetation), but of **short duration** the consequence score is -2.75 (see Table 9-3).

Table 9-3: Consequence of the impact

Score	Source				
	Duration of impact	**Extent**	**Magnitude Intensity**	**Reversibility**	**Nature**
-2.75	Short term 2	National 5	Low 2	Reversible without incurring significant time and cost 2	Negative -1

Step 2: Determine the PROBABILITY of the impact.

Table 9-4: Probability of the impact

Score	Probability
3	Medium probability

Step 3 Determine the ENVIRONMENTAL RISK (ER) of the impact by using the values that were obtained above for Probability and Consequence.

Table 9-5: Environmental risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	**9**	12	15
	2	2	4	**6**	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

Applying the criterion given above, the significance for the proposed exploration is given in Table 9-6.

Table 9-6: Environmental Risk Score

Description	ER Score
Low (i.e. where this impact is unlikely to be a significant environmental risk)	<9

9.5 Physical Risks of Climate Change on the Project's Operations

Since the Project is of a temporary nature and expected to be completed in the near future, **changes in meteorological parameters are not expected to have a significant impact on the Project.**

9.5.1 Temperature

With the increase in temperature, including heat waves, there is the likelihood of an increase in human discomfort, possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Although these have the potential to negatively affect future performance and productivity, it is unlikely to affect staff during the proposed offshore exploration survey as the operations will be completed in the near future.

9.5.2 Rainfall, Water Stress, and Extreme Events

Annual precipitation projections from the CMIP6 model indicate that the total annual rainfall over the region is projected to decrease by between 25 mm and 80 mm. However, it is not expected that this would have any negative effect on the staff performance and productivity. Instead, more noticeable effects could result due to higher tidal regimes and increased wind speeds associated with the storm surges, as already been witnessed (Davis-Reddy and Vincent 2017). Albeit with low confidence, heavy rainfall events (more than 20 mm per 24 hours) will potentially increase. Although this may have the potential to negatively affect the operation of the vessels and helicopter, it is unlikely for the proposed Project as the operations will be completed in the near future.

9.5.3 Transitional Risks and Opportunities of Climate Change on the Project's Operations

Although the financial risk is out of the scope of the of work, the Taskforce for Climate-related Financial Disclosures (TCFD) advocates the disclosure of the financial risks associated with climate change impacts on organisations (TCFD, 2020). These include physical risks resulting in large-scale financial losses caused by storms, droughts, wildfires, and other extreme events.

The Taskforce also advocates the quantification of transitional risks associated with the adjustment to low carbon economies, such as the rapid loss in the value of assets due to policy changes or consumer preference; and financial risks to the economy through elevated credit spreads, greater precautionary saving and rapid pricing readjustment (TCFD, 2020). Along with risks, the Taskforce encourages organisations to identify possible opportunities that could build resilience in economies shifting due to climate change. However, **due to the temporary nature of the Project, this risk is considered to be a non-issue.**

10 MANAGEMENT PLAN

The principal sources of GHG emissions will be exhaust gas emissions produced by the combustion of fuel in engines for vessels and to a minor extent from the helicopter. Flaring could contribute to emissions, however information on flaring is currently uncertain, and as a result it was assumed that flaring would occur for 10 days per exploration period. The burning of oil was assumed to range between 100 to 1000 bbl per day, and the flaring of gas was assumed to be 30 MMscfd.

Associated gas brought to the surface with crude oil during oil production is sometimes disposed of at offshore facilities by venting or flaring. This practice is now widely recognized to be a waste of valuable resources as well as a significant source of GHG emissions (and based on the assumptions, the major source of GHG for this project). At this stage information on flaring is currently uncertain, however general control measures for flaring of gas given by the World Bank Group can be found in Appendix E. The applicant stated in the RFI in the Info folder that "During testing the gas flaring is normally limited to a max of 30MMscfd gas. Oil will be burnt through the flare boom, rates vary between 100 to 1000 bbl/day but only for a max duration of 4 hours."

11 CONCLUSION

11.1 Main Findings

The assessment was based on Scope 1 **GHG emissions** for the proposed exploration in a portion of Block 3B/4B. The calculated CO_2-e emissions is estimated at a total of 31.87 kt. The GHG emissions were estimated using SA specific caloric values and densities for fuels (where available) and IPCC emission factors.

Based on the published 2020 National GHG annual Inventory for South Africa, the maximum total CO_2-e emissions from the Project, assuming a maximum survey duration of 84 days, would contribute approximately 0.008% to the 2020 South African "energy" sector total of 379 505.2 kt CO_2-e and represent a contribution of 0.007% to the 2020 National GHG inventory total of 468 811.7 kt CO_2-e (excluding FOLU).

The EBRD classifies projects contributing more than 25 kt CO_2-e per year to have significant GHG emissions (EBRD 2019). Although the GHG emissions are expected to be above this threshold, it is less than the DFFE PPP requirement threshold of 100 kt CO_2-e. Given that the negative impact is of low intensity, national extent, irreversible (due to its limited period of emission and future uptake by vegetation), but of short duration, the environmental risk is **low.**[16]

Since the Project is of a temporary nature and expected to be completed in the near future, changes in meteorological parameters are not expected to have a significant impact on the Project.

11.2 Recommendations

The means to minimise air emissions from the Project would be achieved by implementing a maintenance plan to ensure all ship engines and boilers receive adequate maintenance to minimise unburnt fuel released to the atmosphere and maximize energy efficiency.

11.3 Possible Permitting and Reporting Requirements

NEM:AQA also provides for the monitoring and reporting of GHG emissions. As per the National Greenhouse Gas Emission Reporting Regulations and the Methodological Guidelines for Quantifying of GHG Emissions (2022), the IPCC default emission factors are to be used together with country-specific density and calorific values for the fuel used. The Regulations require that CO_2 and CH_4 levels (calculated based on Tier 2 or 3 methodologies) be reported on annually via the SAGERS.

Carbon tax (Carbon Tax Act (Act 15 of 2019)) needs to be estimated based on the requirements and tax allowances.

The *Declaration of Greenhouse Gases as Priority Pollutants* require certain processes to submit a PPP to the Minister for approval. The production process does not involve the emissions of GHG in excess of 100 kt. Thus, although reporting is required via SAGERS, it may be concluded that the current project does not require a PPP.

[16] This may also be viewed as a relative contribution to a "South African carbon budget". The AR6 showed that the world can emit only about 500 Gt of CO_2 starting January 1, 2020 for a 50% chance of limiting warming to 1.5°C. For a 67% chance of avoiding 1.5°C, the budget will come down to 400 $GtCO_2$. For a 50% chance of limiting temperatures to 2°C, the world can emit 1 350 $GtCO_2$; and 1 150 $GtCO_2$for a 67 per cent chance. Assuming South Africa's share of this global budget to be based on the 2021 national population figure of 59.31 million people and as a percentage of the 2021 global population of 7.888 billion people, then South Africa's carbon budget in this respect is approximately 8.6 to 10.2 Gt CO_2-e per year. The exploration activities will therefore contribute to the further depletion of the available South African carbon budget by about 0.0003%.

12 ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

Several assumptions had to be made in the study. These, along with other limitations are listed below and should be noted when interpreting the outcomes of the study:

- The quantification of sources of emission was restricted to emissions of sources as provided by the client.
- The fuel assumed to be consumed by these sources was also provided by the client.
- As the details of the venting and flaring are not yet certain, it was assumed that flaring may occur for 10 days during the exploration project. The applicant stated in the RFI in the Info folder that "During testing the gas flaring is normally limited to a max of 30MMscfd gas. Oil will be burnt through the flare boom, rates vary between 100 to 1000 bbl/day but only for a max duration of 4 hours."
- No incineration of waste was assumed to occur on board the vessels.
- Where a range of emission factors were available, the upper range was used in the screening assessment as a worst-case estimate.
- The drill rig was assumed to be a mobile combustion source, however it will be both stationary and mobile.

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14 APPENDICES

APPENDIX A: SPECIALIST DECLARATION FORM

APPENDIX B: CURRICULUM VITAE OF PROJECT TEAM

CURRICULUM VITAE

Name	Gillian Petzer (née Möhle)
Date of Birth	1 December 1975
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Principal Consultant and Project Manager
Profession	Chemical Engineer employed as an Air Quality Assessment Consultant
Years with Firm	19 years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- South African Institute of Chemical Engineers, 2003 to present
- Institution of Chemical Engineers (IChemE) - Membership number 99964317
- National Association for Clean Air (NACA), 2003 to present
- Professional Engineer – Registration number 20170315

EXPERIENCE

Gillian has nineteen years of experience in air quality impact assessment and management. She is an employee of Airshed Planning Professionals (Pty) Ltd and is involved in the compilation of emission inventories, air pollution mitigation and management, and air pollution impact work.

A list of projects competed in various sectors is given below.

Air Quality Management

- Richards Bay Air Quality Management Plan
- Tshwane Air Quality Management Plan
- Dust Management Plan for various mines

Mining Sector

Lusthof Colliery, South Deep Mine, Kangra, MacWest, Sishen Iron Ore Mine, SA Chrome, Esaase Gold Project (Ghana), Mampon Gold Mine (Ghana), Mittal Newcastle, Navachab (Namibia), Skorpion Zinc mine (Namibia), Debswana Diamond Mines (Botswana). Quarries: Afrisam Pietermaritzburg, AMT operations (Rustenburg and Wonderstone)

Industrial Sector

Various Brickworks, Middelburg Ferrochrome, Impala Platinum (Springs), Delta EMD Project, PetroSA, Alfluorco Aluminium Fluoride Project, PPC, Rand Carbide, Vanchem, BCL incinerator, AEL, Namakwa Sands Plant, Liquid Natural Gas Refinery (Equatorial Guinea), Phalaborwa Mining Company, Asphalt plants, Ceramic facilities

Energy Sector

Walvis Bay Power Station Project (Namibia), various small power stations (Eritrea, Nigeria, Mauritania, Kenya), Matimba Power Station, Mossel Bay OCGT Power Station, Sese Power Station (Botswana), Geothermal Power Station (Kenya)

Waste Disposal and Treatment Sector

Rosslyn and Chloorkop Waste Disposal Sites, Organic waste disposal site

Transport and Logistics Sector

Kolomela Iron Ore Railway Line, Guinea Port and Railway Project (Guinea), Grindrod Coal Terminal, VALE Port Project (Mozambique), various fuel depots.

Ambient Air Quality and Noise Sampling

- Gravimetric Particulate Matter (PM) and dustfall sampling
- Passive diffusive gaseous pollutant sampling

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM, TANKS
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

- BEng: (Chemical Engineering), 2002, University of Pretoria

COURSES COMPLETED AND CONFERENCES ATTENDED

- Conference: NACA (October 2003), Attended
- Conference: NACA (October 2005), Attended and presented a paper
- Conference: NACA (October 2007), Attended and presented a paper
- Conference: NACA (October 2008), Attended and presented a poster
- Conference: NACA (October 2009), Attended and presented a paper
- Conference: NACA (October 2012), Attended
- Conference: IUAPPA (October 2013), Attended
- Course: Climate change and carbon management. Presented by Environmental & Sustainability Solutions (July 2014)
- Conference NACA (October 2016), Attended
- Conference NACA (October 2017), Attended
- Process Vessel and Tank Design Course (May 2019), Attended

COURSES PRESENTED

- National Environmental Management: Air Quality Act and its Implementation (course arranged by the North-West University - NWU)

COUNTRIES OF WORK EXPERIENCE

South Africa, Namibia, Botswana, Ghana, Eritrea, Mauritania, Mozambique, Kenya, Guinea, Equatorial Guinea and Nigeria

LANGUAGES

Language	Proficiency
English	Native language
Afrikaans	Full professional proficiency

REFERENCES

Name	Position	Contact Number
Dr. Gerrit Kornelius	Associate of Airshed Planning Professionals	+27 (82) 925 9569 gerrit@airshed.co.za

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Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.

28/04/2022

Appendix C: Impact Significance Rating Methodology

The impact significance rating methodology, as presented herein and utilised for all EIMS Impact Assessment Projects, is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. The ER is determined for the pre- and post-mitigation scenario. In addition, other factors, including cumulative impacts and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

<u>Determination of Environmental Risk:</u>
The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER). The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and Reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$C = \frac{(E + D + M + R) * N}{4}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table C-1 below.

Table C-1: Criteria for determining impact consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or

Aspect	Score	Definition
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/scored as per Table C-2.

Table C-2: Probability scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

$$ER = C \times P$$

Table C-3: Determination of environmental risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table -4.

Table C-4: Significance classes

Environmental Risk Score	
Value	**Description**
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
≥9; <17	Medium (i.e. where the impact could have a significant environmental risk),
≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

Impact Prioritisation:

Further to the assessment criteria presented in the section above, it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table C-5: Criteria for determining prioritisation

Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table C-5. The impact priority is therefore determined as follows:

$$Priority = CI + LR$$

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from 1 to 1.5 (refer to Table C-6).

Table C-6: Determination of prioritisation factor

Priority	Prioritisation Factor
2	1
3	1.125
4	1.25
5	1.375
6	1.5

In order to determine the final impact significance, the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is an attempt to increase the post mitigation environmental risk rating by a factor of 0.5, if all the priority attributes are high (i.e. if an impact comes out with a high medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table C-7: Final environmental significance rating

Significance Rating	Description
≥-17	High negative (i.e. where the impact must have an influence on the decision process to develop in the area).
≥-17, ≤-9	Medium negative (i.e. where the impact could influence the decision to develop in the area).
>-9, <0	Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).
0	No impact
>0, <9	Low positive (i.e. where this impact would not have a direct influence on the decision to develop in the area).
≥9, ≤17	Medium positive (i.e. where the impact could influence the decision to develop in the area).
>17	High positive (i.e. where the impact must have an influence on the decision process to develop in the area).

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.

APPENDIX D: AR5 AND AR6 CLIMATE CHANGE SCENARIO DEFINITIONS

The climate change projections in this report discuss results from both the latest IPCC's and the South African Weather Service (SAWS) simulations. The SAWS study based the climate change scenarios on the four Representative Concentration Pathways (RCPs) as discussed in the IPCC's Fifth Assessment Report (AR5) (IPCC 2013). RCPs are defined by their influence on atmospheric radiative forcing in the year 2100. A RCP is a GHG concentration (not emissions) trajectory adopted by the IPCC. The RCPs, originally RCP2.6, RCP4.5, RCP6, and RCP8.5, describe different climate change scenarios, all of which are considered possible depending on the amount of GHG emitted in the years to come. The RCPs were labelled after a possible range of radiative forcing values in the year 2100 (2.6, 4.5, 6, and 8.5 W/m², respectively). The higher values mean higher GHG emissions and therefore higher global temperatures and more pronounced effects of climate change. The lower RCP values, on the other hand. are more desirable for humans but require more stringent climate change mitigation efforts to achieve them:

- RCP 1.9 is a pathway that limits global warming to below 1.5 °C, the aspirational goal of the Paris Agreement.
- RCP 2.6 is a "very stringent" pathway and requires that CO_2 emissions start declining by 2020 and go to zero by 2100. It also requires that CH_4 go to approximately half the CH_4 levels of 2020, and that SO_2 emissions decline to approximately 10% of those of 1980–1990.
- RCP 3.4 represents an intermediate pathway between the "very stringent" RCP2.6 and less stringent mitigation efforts associated with RCP4.5, below.
- RCP 4.5 is described by the IPCC as an "intermediate scenario". GHG emissions peak around 2045, then CO_2 emissions start declining to reach roughly half of the levels of 2050 by 2100. It also requires that CH_4 stop increasing by 2050 and decline to about 75% of the CH_4 levels of 2040, and that SO_2 emissions decline to approximately 20% of those of 1980–1990.
- RCP 6 emissions peak around 2080, then decline. This scenario includes continuous global warming through 2100 where CO_2 levels rise to 670 ppm by 2100 making the global temperature rise by about 3–4 °C by 2100. The scenario uses a high GHG emission rate and is a stabilisation scenario where total radiative forcing is stabilised after 2100 by employment of a range of technologies and strategies for reducing GHG emissions.
- RCP7 is a baseline outcome rather than a mitigation target.
- RCP 8.5 emissions continue to rise throughout the 21st century, which is, generally taken as the basis for worst-case climate change scenarios.

The two most typically RCPs selected are RCP4.5 representing the "intermediate" or "medium-to-low" pathway and RCP8.5 representing the "high" pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. In other words, RCP4.5 is based on the assumption that current interventions to reduce GHG emissions are sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on the assumption that no interventions to reduce GHG emissions are implemented (after 2100 the concentration is expected to continue to increase). In 2017 the SAWS published the Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections (SAWS, 2017). The projections are for 30-year periods described as the *near future* (2036 to 2065) and the *far future* (2066 to 2095). Projected changes are defined relative to a historical 30-year period (1976 to 2005). The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°.

The most recent IPCC data are from the Coupled Model Intercomparison Project (CMIP) which were derived from the sixth phase of the CMIPs (CMIP6) and supports the IPCC's Sixth Assessment Report (AR6) which was released on 9 August 2021 (Working Group I), 28 February 2022 (Working Group II and 4 April 2022 (Working Group III). Projection data is presented at a 1.0º x 1.0º (100km x 100km) resolution. Different from the previous AR5 RCP scenarios, the AR6 report uses five possible scenarios for the future (Table D-1). The scenarios are the result of complex calculations that depend on how quickly humans curb greenhouse gas emissions, whilst also capturing socioeconomic changes in areas such as population, urban density, education, land use and wealth. For example, a rise in population is assumed to lead to higher demand for fossil fuels and water. Education can affect the rate of technology developments. Emissions increase when land is converted from forest to agricultural land. Each scenario is labelled to identify both the emissions level and the so-called Shared Socioeconomic Pathway, or SSP, used in those calculations. This first scenario is the only one that meets the Paris Agreement's goal of keeping global warming to around 1.5°C above preindustrial temperatures, with warming hitting 1.5°C but then dipping back down and stabilizing around 1.4°C by the end of the century. Projected changes are defined relative to a historical 20-year period (1995 to 2014).

Table D-1: Possible climate change scenarios adopted in AR6

Identifier	Scenario	Description
SSP1-1.9	Most optimistic: 1.5°C by 2050	The IPCC's most optimistic scenario, this describes a world where global CO_2 emissions are cut to net zero around 2050. Societies switch to more sustainable practices, with focus shifting from economic growth to overall well-being. Investments in education and health go up. Inequality falls. Extreme weather is more common, but the world has dodged the worst impacts of climate change.
SSP1-2.6	Next Best: 1.8°C by 2100	In the next-best scenario, global CO_2 emissions are cut severely, but not as fast, reaching net-zero after 2050. It imagines the same socioeconomic shifts towards sustainability as SSP1-1.9. But temperatures stabilize around 1.8°C higher by the end of the century.
SSP2-4.5	Middle of the road: 2.7°C by 2100	This is a "middle of the road" scenario. CO_2 emissions hover around current levels before starting to fall mid-century, but do not reach net-zero by 2100. Socioeconomic factors follow their historic trends, with no notable shifts. Progress toward sustainability is slow, with development and income growing unevenly. In this scenario, temperatures rise 2.7°C by the end of the century.
[**SSP3-7.0**]:	Dangerous: 3.6°C by 2100	On this path, emissions and temperatures rise steadily and CO_2 emissions roughly double from current levels by 2100. Countries become more competitive with one another, shifting toward national security and ensuring their own food supplies. By the end of the century, average temperatures have risen by 3.6°C.
SSP5-8.5]:	Avoid at all costs: 4.4°C by 2100	This is a future to avoid at all costs. Current CO_2 emissions levels roughly double by 2050. The global economy grows quickly, but this growth is fuelled by exploiting fossil fuels and energy-intensive lifestyles. By 2100, the average global temperature is a scorching 4.4°C higher.

Appendix E: World Bank Recommendations on Flaring and Venting and Well Testing (World Bank Group, 2015)

Associated gas brought to the surface with crude oil during oil production is sometimes disposed of at offshore facilities by venting or flaring. This practice is now widely recognized to be a waste of valuable resources as well as a significant source of GHG emissions.

However, flaring and venting are important safety measures on offshore oil and gas facilities, helping to ensure that gas and other hydrocarbons are safely disposed of in the event of an emergency, a power or equipment failure, or other facility upset condition. Risk assessment processes (e.g., hazard and operability study (HAZOP), hazard identification study (HAZID), etc.) to estimate the implications of situations of this type should be used in such facilities.

Measures consistent with the Global Gas Flaring and Venting Reduction Voluntary Standard (part of the Global Gas Flaring Reduction Public-Private Partnership) should be adopted when considering venting and flaring options for offshore activities. The standard provides guidance on how to eliminate or achieve reductions in the flaring and venting of natural gas.

Continuous venting of associated gas is not good practice and should be avoided. The associated gas stream should be routed to an efficient flare system, although continuous flaring of gas should be avoided if alternatives are available. Before flaring is adopted, all feasible alternatives for the gas's use should be evaluated to the maximum extent possible and integrated into production design. Alternative options may include gas utilization for on-site energy needs, gas injection for reservoir pressure maintenance, enhanced oil recovery using gas lift, or export of the gas to a neighbouring facility or to market. An assessment of alternatives should be made and adequately documented. If none of the options for the associated gas's use is feasible, measures to minimize flare volumes should be evaluated and flaring should be considered as an interim solution, with the elimination of continuous production associated gas flaring as the preferred goal.

New facilities should be designed, constructed, and operated so as to avoid routine flaring. Cost effective options to reduce flaring from existing or legacy facilities that offer sustainable social benefits (e.g., gas-to-power) should be identified and evaluated in collaboration with host country governments and other stakeholders and with a particular focus on GHG emissions.

If flaring is the only viable solution, continuous improvement of flaring through the implementation of good practices and new technologies should be demonstrated. The following pollution prevention and control measures should be considered for gas flaring:

- Implement source gas reduction measures to the extent possible.
- Use efficient flare tips and optimize the size and number of burning nozzles.
- Maximize flare combustion efficiency by controlling and optimizing flare fuel, air, and stream flow rates to ensure the correct ratio of assist stream to flare stream.
- Minimize flaring from purges and pilots—without compromising safety—through measures including installation of purge gas reduction devices, vapor recovery units, inert purge gas, soft seat valve technology where appropriate, and installation of conservation pilots.
- Minimize risk of pilot blowout by ensuring sufficient exit velocity and providing wind guards.
- Use a reliable pilot ignition system.
- Install high-integrity instrument pressure protection systems, where appropriate, to reduce overpressure events and avoid or reduce flaring situations.
- Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system.

- Minimize flame lift off and/or flame lick.
- Operate flare to control odor and visible smoke emissions (no visible black smoke). Situate flare at a safe distance from accommodation units.
- Implement burner maintenance and replacement programs to ensure continuous maximum flare efficiency.
- Meter flare gas.

In the event of an emergency or equipment breakdown, or when facility upset conditions arise, excess gas should not be vented but rather should be sent to an efficient flare gas system. Emergency venting may be necessary under specific field conditions where a flare gas system is not available or when flaring of the gas stream is not possible, such as when there is a lack of sufficient hydrocarbon content in the gas stream to support combustion or a lack of sufficient gas pressure to allow it to enter the flare system. Justification for excluding a gas flaring system on offshore facilities should be fully documented before an emergency gas venting facility is considered.

To minimize flaring events as a result of equipment breakdowns and facility upsets, plant reliability should be high (>95 percent) and provisions should be made for equipment sparing and plant turn-down protocols.

Flaring volumes for new facilities should be estimated during the initial commissioning period so that appropriate flaring targets can be developed. The volumes of gas flared for all flaring events should be recorded and reported.

During well testing, flaring of produced hydrocarbons should be avoided, especially in environmentally sensitive areas. Feasible alternatives should be evaluated for the recovery of these test fluids, with the safety of handling volatile hydrocarbons considered, either for transfer to a processing facility or for alternative disposal options. An evaluation of alternatives for produced hydrocarbons should be adequately documented.

If flaring is the sole option available for the disposal of test fluids, only the minimum volume of hydrocarbons required for the test should be flowed and well-test durations should be reduced to the extent practical. An efficient test flare burner head equipped with an appropriate combustion enhancement system should be selected to minimize incomplete combustion, black smoke, and hydrocarbon fallout to the sea. Volumes of hydrocarbons flared should be recorded.