Climate Change Assessment Report for Cluster 2 of the Gas Gathering Project in Virginia, South Africa

Project done on behalf of **EIMS (Pty) Ltd**

Report Compiled by:
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Report Details

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Reviewed by	Terri Bird (Pr. Sci. Nat.), PhD (University of Witwatersrand) Hanlie Liebenberg-Enslin, PhD (University of Johannesburg)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in air quality and environmental noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	I, Hanlie Liebenberg-Enslin, as authorised representative of Airshed Planning Professionals (Pty) Ltd, hereby confirm my independence as a specialist and declare that neither I nor Airshed Planning Professionals (Pty) Ltd have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Airshed Planning Professionals (Pty) Ltd was appointed as air quality specialists in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998); other than fair remuneration for worked performed, specifically in connection with the assessment summarised in this report. I also declare that I have expertise in undertaking the specialist work as required, possessing working knowledge of the acts, regulations and guidelines relating to the application. I further declare that I am able to perform the work relating to the application in an objective manner, even if this result in views and findings that is not favourable to the application; and that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in this report.
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Revision Record

Revision Number	Date	Reason for Revision
Draft Rev 0	13 July 2022	For client review
Final Rev 1	18 July 2022	Addressed client comments
Final Rev 2	25 October 2022	Included Scope 3 GHG emissions
Final Rev 3	27 October 2022	Addressed client comments

Competency Profiles

Report author and Project Manager: H Liebenberg-Enslin, PhD Geography (University of Johannesburg).

After earning her master's degree in science from the University of Johannesburg (formerly RAU) in Geography and Environmental Management. Hanlie Liebenberg-Enslin began her professional career in air quality management in 2000 when she joined Environmental Management Services (EMS). The same department at the University of Johannesburg awarded her a PhD in June 2014 with a focus on aeolian dust transport. She is one of the founding members of Airshed Planning Professionals and served as a director of the organization until May 2013, when she assumed the role of managing director.

She has worked across Africa and has considerable experience in the many aspects of air quality management, including impact- and health risk screening assessments, dispersion modelling simulations, and emissions quantification for a variety of source types. Hanlie has been involved in a few United Nations Environmental Programme (UNEP) projects and served as the project manager on numerous innovative air quality management plan (AQMP) developments. She also participates actively in the National Association for Clean Air (NACA) and the International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA). She served as an external examiner for various MSc and PhD dissertations and lectured at air quality management courses.

Report author: R Bornman (M.Phil in GIS and Remote Sensing, University of Cambridge)

Rochelle Bornman started her professional career in Air Quality in 2008 when she joined Airshed Planning Professionals (Pty) Ltd after having worked in malaria research at the Medical Research Council in Durban. Rochelle has worked on several air quality specialist studies between 2008 and 2022. She has experience on the various components 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. Whilst most of his working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Mozambique, Namibia, Saudi Arabia and Mali.

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

Gillian has been with Airshed since 2003. She holds a bachelor's degree in chemical engineering from the University of Pretoria. Her experience in air quality started in 2000 with the "Indoor Air Quality" division of Building Research Establishment (BRE) in the UK. Over the last two decades she has been actively involved in the development of atmospheric dispersion modelling and its applications, air pollution compliance assessments, health risk assessments, mitigation measures, development of air quality management plans, as well as meteorological and air quality monitoring programmes. She registered as a professional engineer in 2017. Whilst most of her working experience has been in South Africa, a number of investigations were made in countries throughput Africa as well as recent countries such as Afghanistan and Armenia.

Report reviewer: Dr Theresa (Terri) Bird, Pr. Sci. Nat., PhD (University of the Witwatersrand)

Dr Terri Bird holds a PhD from the School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg. The focus of her doctoral research was on the impact of sulfur and nitrogen deposition on the soil and waters of the Mpumalanga Highveld. Since March 2012 she has been employed at Airshed Planning Professionals (Pty) Ltd. In this time, she has been involved in air quality impact assessments for various mining operations (including coal, mineral sand, diamond and platinum mines) as well as coal-fired power station ash disposal facilities. She has been a team member on the development of Air Quality Management Plans, both provincial and for specific industries. Recent projects include assessing the impact of Postponement and/or Exemption of Emission Standards for various Listed Activities.

Executive Summary

Tetra4 wishes to expand the natural gas operations within the approved production right area and around the Cluster 1 project. This planned expansion to the existing approved production activities will involve up to 300 new production wells, gas transmission pipelines and associated infrastructure, three (3) compressor stations and an additional new combined Liquid Natural Gas (LNG) and Liquid Helium (LHe) plant ("LNG/LHe Plant") and associated infrastructure.

A Climate Change Assessment (CCA) was conducted to determine the potential long term climate change impacts as a result of the Tetra4 Cluster 2 operations. Greenhouse gas (GHG) emissions for the project were calculated based on the Department of Forestry, Fisheries and Environment (DFFE) 2022 Methodological guidelines for quantification of GHG emissions which are based on the Intergovernmental Panel on Climate Change (IPCC) emission factors. This study considered Scope1, Scope 2 and Scope 3 emissions, where Scope 1 are the emissions directly attributable to the project and Scope 2 emissions are the emissions associated with bought-in electricity. Scope 3 emissions consider the "embedded" carbon in bought-in materials and transport as well as the use of exported materials. Only Scope 1 emissions need to be quantified to be in line with the DFFE guidelines; the addition of Scope 2 would place the assessment in line with the guidelines provided by the International Finance Corporation (IFC).

The conclusions and recommendations of the assessment are summarised below:

- The region around Welkom and Virginia where Tetra4 Cluster 2 project is proposed to be developed is likely to experience increased temperatures and extreme weather-related events in the future. Climate change impacts will disproportionately affect under-developed communities that lack the physical and financial resources to cope with the physical effects of climate change, such as droughts, floods and increases in diseases.
- Scope- 1, 2 and 3 emissions were estimated based on emission factors and expected production rates or raw material use. The main construction activities attributing to GHG emissions are well drilling, well testing and well servicing followed by off-road mobile equipment. During operations, the electricity bought from ESKOM (Scope 2) is the main source, followed by road transportation and gas process venting (Scope 1). The main source of Scope 3 GHG emissions would be the end use of the LNG, but as LNG will be replacing other fuels already in use, it will result in a reduction of 14.6% in indirect GHG emissions.
- Construction- and operational-related GHG emissions from the proposed Tetra4 Cluster 2 project cannot be attributed directly to any particular climate change effects, and, when considered in isolation, will have a Low to Medium impact on the National GHG inventory total. The main GHG impact is associated with downstream use of the LNG, i.e. Scope 3. GHG emissions per unit of gas combusted, however, is less than per unit coal.
- Since climate change is a global challenge, there is a collective responsibility to address climate change and Tetra4 has an individual responsibility to minimise its own negative contribution to the issue. It is recommended that renewable energy (such as photovoltaic solar panels) be considered to replace/ reduce the reliance on ESKOM electricity which is likely to reduce the significance from the Tetra4 Cluster 2 project from Medium to Low, since ESKOM's contribution to the operational phase is the main source of GHG emissions. Also, the use of LNG instead of diesel will reduce the GHG footprint further. Maintenance of vehicles and machinery, the implementation of a leak-detection program, and the minimisation of flaring and venting would reduce the potential for GHG emissions.
- Once operational, it is recommended records be kept of actual fuel usage for transport of materials and products, energy requirements, production rates, flare and venting rates and raw material consumption for GHG reporting purposes and refinement of the emissions inventory.

Based on Tetra4 Cluster 2 Scope 1, 2 and 3 GHG emissions, it is the specialist opinion that the project may be authorised due to its low to medium impact significance.

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Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
AR5	IPCC Fifth Assessment Report
CCRA	Climate Change Reference Atlas
CCS	Carbon Capture and Sequestration (or Carbon Capture and Storage)
COP	Conference of the Parties
DEA	Department of Environmental Affairs (now DEFF)
DEFRA	United Kingdom's Department of Environment, Food and Rural Affairs
DFFE	Department of Forestry, Fisheries and Environment (previously DEA)
EIA	Environmental Impact Assessment
EIMS	Environmental Impact Management Services (Pty) Ltd
ETF	Enhanced transparency framework
FOLU	Forestry and Other Land Use
GCMs	Global Climate Change Models
GHGIP	National Greenhouse Gas Improvement Programme
GWP	Global Warming Potential
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IPPU	Industrial Processes and Other Product Use
IRP	Integrated Resource Plan
LT-LEDS	Long-term low greenhouse gas emission development strategies
NAEIS	National Atmospheric Emissions Inventory System
NCCRP	National Climate Change Response Plan
NDC	Nationally Determined Contribution
NDCR	National Dust Control Regulations
NEMAQA	National Environmental Management Air Quality Act
PPP	Pollution Prevention Plan
RCPs	Representative Concentration Pathways
SAAELIP	South African Atmospheric Emission Licencing and Inventory Portal
SAAQIS	South African
SAGERS	South African Greenhouse Gas Emission Reporting System
SAWS	South African Weather Services
UNFCCC	United Nations Framework Convention on Climate Change

Symbols and Units

°C	Degree Celsius
C_6H_6	Benzene
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-eq	Carbon dioxide equivalent
ha	Hectare
HFC	Hydrofluorocarbons
kg	Kilograms
1 kilogram	1 000 grams
km	Kilometre
m	Metres
mm	Millimetres
mamsl	Metres above mean sea level
m/s	Metres per second
mm	Millimetres
NO	Nitrogen oxide
N_2O	Nitrous oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Ozone
Pb	Lead
PFC	Perfluorocarbons
$PM_{2.5}$	Inhalable particulate matter (aerodynamic diameter less than 2.5 µm)
PM_{10}	Thoracic particulate matter (aerodynamic diameter less than 10 µm)
SF6	Sulfur hexafluoride
SO_2	Sulfur dioxide (1)
tpa	Tonnes per annum
1 ton	1 000 000 grams

Notes:
The spelling of "sulfur" has been standardised to the American spelling throughout the report. The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, published, in 1990, a list of standard names for all chemical elements. It was decided that element 16 should be spelled "sulfur". This compromise was to ensure that in future searchable data bases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.doi: 10.1351/goldbook)"

1 INTRODUCTION

Tetra4 holds the first and only onshore petroleum production right in South Africa, making Tetra4 the front runner in domestic natural gas distribution. A Production Right (Ref: 12/4/1/07/2/2) was granted in 2012, spanning approximately 187 000 hectares (ha) for the development of natural gas (Helium and Methane) production operations around the town of Virginia in the Free State Province. Within this approval, the 2010 Environmental Management Programme (EMPr) was approved which is applicable to a large portion of the Production Right area (Figure 1). Activities within the Production Right areas include:

- Continued exploration activities;
- Drilling and establishment of further production wells throughout the entire production area (260 production wells);
- Installation of intra-field pipelines throughout the entire production area (~500 km);
- Installation of boosters and main compressors; and
- Central gas processing plant (not approved in the original Environmental Impact Assessment (EIA) and approved EMPr).

An integrated environmental authorisation (EA) for the first phase gas field production referred to as Cluster 1, in terms of the National Environmental Management Act (NEMA), was issued on 21 September 2017 by the Department of Mineral Resources and Energy (DMRE) to Tetra4 ("Cluster 1 EA", reference: 12/04/07) and amended on 26 August 2019 and 1 September 2020. In this EA approval, various new wells and pipelines, booster and compressor stations, a Helium and Liquid Natural Gas (LNG) Facility and associated infrastructure was approved which comprises the first gas field for development within the approved Production Right area. The Cluster 1 EA also authorises certain waste management activities as per the List of Waste Management Activities (Government Notice 921, as amended) published under the National Environmental Management: Waste Act 59 of 2008 (NEMWA).

Tetra4 now plans to expand the natural gas operations (referred to as Cluster 2) to be located within the approved production right area and around the Cluster 1 project (Figure 2). This planned expansion to the existing approved production activities will include:

- Drilling and establishment of further production wells (up to 300 new production wells);
- Installation of gas transmission pipelines and associated infrastructure;
- Installation of three (3) compressor stations;
- An additional new combined LNG and Liquid Helium (LHe) plant ("LNG/LHe Plant") and associated infrastructure, and
- Establishment of powerlines as part of the Cluster 2 expansion of the Project in order to meet the future production requirements.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Environmental Impact Management Services (EIMS) (Pty) Ltd to conduct a Climate Change Assessment (CCA) for the project. The main objective is to quantify the greenhouse gasses (GHG) associated with the project and the potential long term climate change impacts as a result.

1.1 Study Objective

The main objective of the CCA is to quantify the greenhouse gasses (GHG) associated with the project and to determine the significance of potential climate change impacts as a result.

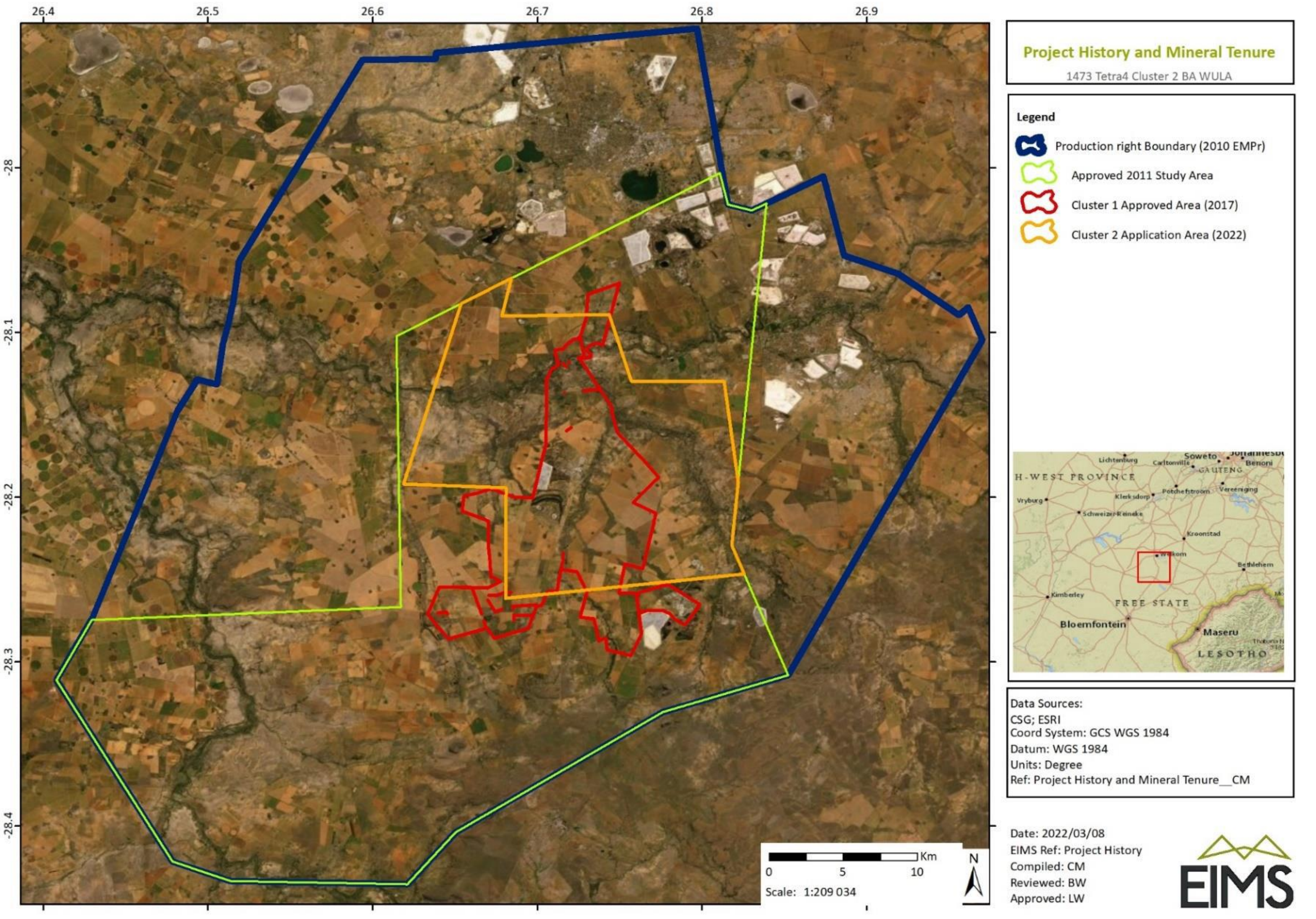

Figure 1: Project history and mineral tenure

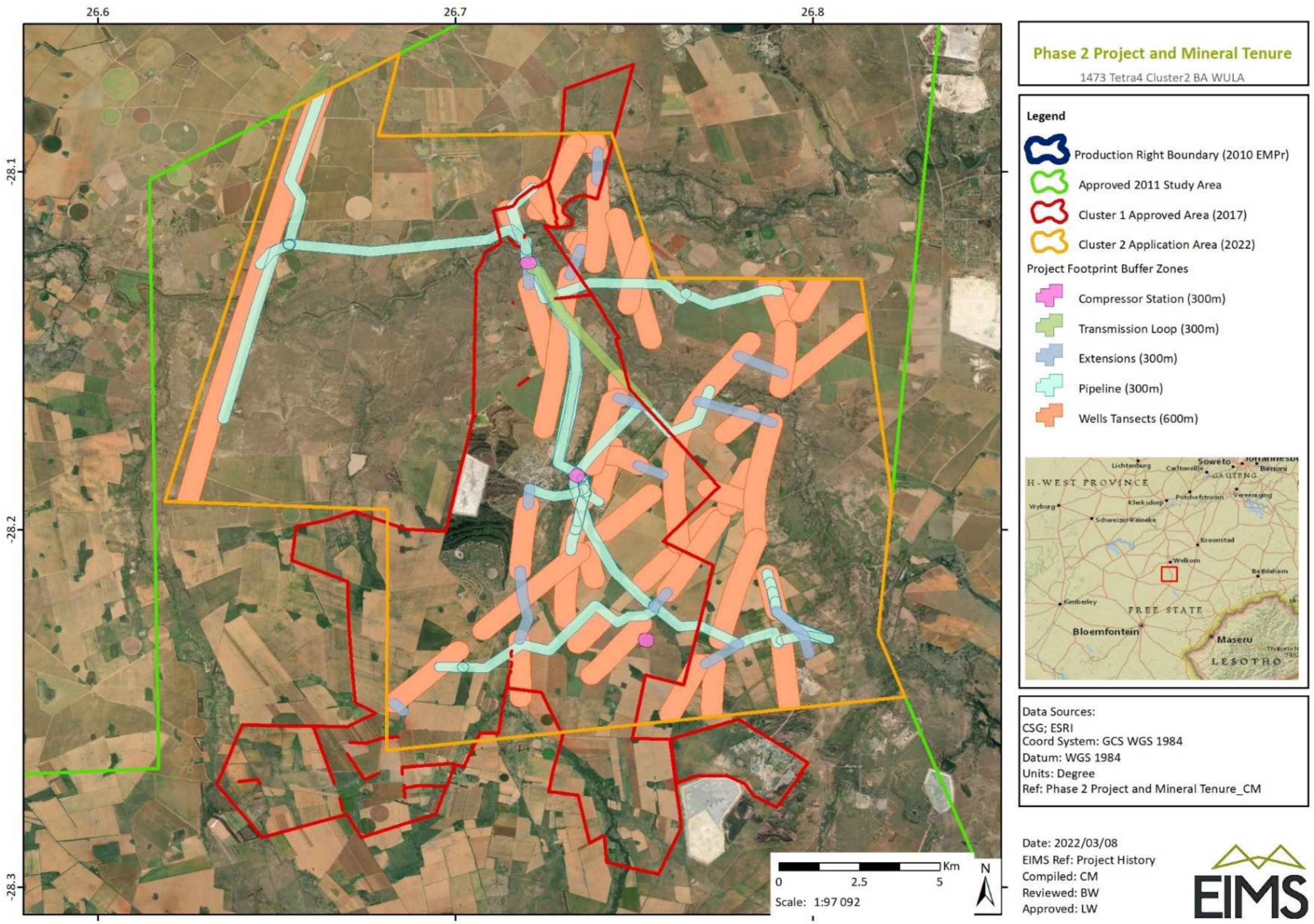

Figure 2: Cluster 2 study area and proposed infrastructure footprint buffer zones

1.2 Scope of Work

The tasks proposed as part of the scope of work for the CCA for the Construction and Operational Phases of the project, are:

- Identification of the Transitional and Physical Risks associated with the project (as per the Task Force on Climate-related Financial Disclosures).
- GHG emissions during the construction and operation of the project covering Scope1, Scope 2 and Scope 3 emissions.
- Comparison of GHG emissions to the global and national emission inventories, and to international benchmarks for the project.
- The robustness of the project in terms of forecasted climate change impacts to the area over the lifetime of the project.
- The vulnerability of communities in the immediate vicinity of the project to climate change.
- Proposed management and mitigation strategies.
- Compile a report that complies with the requirements of Appendix 6 of the EIA Regulations, 2014 (Government Notice (GN) R 982 of 2014, as amended); and/or
- The Department of Forestry, Fisheries and Environment (DFFE) "Protocols for the assessment and minimum report content requirements of environmental impacts" (GN 320 of 2020 and GN 1150 of 2020); and/or
- Any other applicable sector-specific guidelines and protocols.

1.3 Study Approach and Methodology

GHG emissions for the project were calculated and compared to the global and national emission inventory and compared to international benchmarks for the project.

1.3.1 Project and Information Review

A review of the project from an air quality perspective in order to identify sources of GHG emission was conducted. In the review the following documents were referenced:

- Project information supplied by EIMS, including the AQIA conducted in 2017 (Akinshipe, 2017); and
- Section 21 of the National Environmental Management: Air Quality Act (NEMAQA).

1.3.2 Carbon Footprint Calculation

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

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

where

- *Activity information* relates to the activity that causes the emissions.
- *emission factor* refers to the amount of GHG emitted per unit of activity.
- *GWP* or global warming potential is the potential of an emitted gas to cause global warming relative to carbon dioxide (CO_2). This converts the emissions of all GHGs to the equivalent amount of CO_2 or CO_2-e.

For combustion processes, the emission factor is often calculated from a carbon mass balance, where the combustion of each unit mass of carbon in the fuel leads to an equivalent emission of 3.67 mass units of CO_2 (from 44/12, the ratio of molecular weight of CO_2 to that of carbon).

GWPs from the recently published DFFE guideline on quantification of GHG emissions (based on the IPCC Third Assessment Report, 2001) were applied in this study. These GWPs are compliant with UNFCCC Reporting Requirements. The 100-year GWPs were used: 23 for methane (CH_4) and 296 for nitrous oxide (N_2O).

In the quantification of Scope 1 emissions, the recently published DFFE guideline on quantification of GHG emissions (DFFE, 2022) was used. Scope 3 emissions were estimated using the United Kingdom's Department of Environment, Food and Rural Affairs (UK DEFRA) 2022 emission factors (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022). A summary of the emission factors applied is provided in Appendix A.

1.3.3 Scope of Carbon Footprint

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, etc.

In this study, Scope 1 emissions are the emissions directly attributable to the project and Scope 2 emissions are the emissions associated with bought-in electricity. Scope 3 emissions consider the "embedded" carbon in bought-in materials and transport as well as the use of exported materials. Only Scope 1 emissions need to be quantified to be in line with the DFFE guidelines; the addition of Scope 2 would place the assessment in line with the guidelines provided by the International Finance Corporation (IFC, 2012).

1.3.4 Impact Assessment Methodology

As the emission of greenhouse gases has a global impact, it is not feasible to follow the normal impact assessment methodology viz. comparing the state of the physical environment after implementation of the project to the condition of the physical environment prior to its implementation. Instead, this study assessed the following:

(i) The GHG emissions during the construction, operation and decommissioning of the project compared to the global and South African emission inventory and to international benchmarks for the project.
(ii) The impact of climate change over the lifetime of the project taking the robustness of the project into account.
(iii) The vulnerability of communities in the immediate vicinity of the project to climate change.

1.4 Project Description

1.4.1 Construction

The construction phase comprises activities, such as drilling and construction of new wells, construction of access roads, installation of pipelines, construction of the helium and LNG plant, as well as site clearing or upgrade activities on existing wells. Each of these operations has its own duration and GHG emission potential with typical activities land clearing, topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, compaction, well drilling etc. It is anticipated therefore that the extent of GHG emissions would vary substantially from day to day depending on the level of activity and the specific operations.

1.4.2 Operations

The operational phase of the Project will include mainly the combined LNG/LHe plant with continuous and emergency flares, three electrically powered compressor stations and booster stations that would require natural gas generators. Nitrogen (N_2) will be trucked to the plant, and the LNG and LHe products will be exported by truck from the plant via road. In addition, maintenance vehicles and equipment will operate as needed.

1.5 Assumptions and Limitations

The following important limitation applies to the study and should be noted:

- Project information required to calculate GHG emissions for proposed operations were provided by Tetra4 via EIMS. Where necessary, assumptions were made based on common industry practice and experience.
- The compressor stations were assumed to be electrically powered, whereas the booster stations were assumed to use natural gas generators.
- The methodological guidelines for quantification of GHG emissions (DFFE, 2022), published in October 2022, have been used to estimate the Scope 1 GHG emissions. The 100-year GWPs were used.
- GHG emissions from the well drilling[1], well testing[2], and well servicing[3] were based on measurements provided by the client, and not calculated using emission factors. These activities were included under construction operations.
- Scope 3 emissions were estimated using the UK DEFRA (2022) emission factors (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022).
- The following Scope 3 categories are excluded since these are not regarded applicable to the project:
    - Category 2: Capital Goods
    - Category 8: Upstream Leased Assets
    - Category 10: Processing of Sold Products
    - Category 12: End-of-Life Treatment of Sold Products
    - Category 13: Downstream Leased Assets
    - Category 14: Franchises
    - Category 15: Investments.
- The following assumptions apply to the Scope 3 assessment:
    - Raw materials needed for the wells and plant was assumed to be 100 980 tonne concrete, 26 060 tonne metal and 9 000 tonne HDPE.
    - It was assumed that the raw materials would be transported by truck to site (450 km).
    - Industrial waste to be sent to a landfill was assumed to be 31 428 tpa.
    - Business travel was assumed to be 6 people travelling to USA and Europe per year.
    - It was assumed that contractors and permanent staff (total 1 254 people) would have the following split for employee commuting to work (2.8% diesel car, 4.6% petrol car, 19.6% taxi and 73% bus). It was assumed that the return trip per day was 60 km.
    - It was assumed that 60% of the LNG (~ 90 000 tpa) would be shipped by sea tanker to China.
    - It was assumed that the Helium (1 825 tpa) would be transported by truck to Durban (600 km), and then by ship (cargo ship average bulk carrier) to either Europe, Asia or North America (average 14 461 km).
    - It was assumed that the LNG (~ 160 000 tpa) would be combusted (end use of product).

[1] Data obtained from kestrel flow meter while drilling and extrapolated for duration of exploration drilling in gas bearing units.
[2] Data obtained from flow testing and flaring of existing exploration wells.
[3] Data obtained from fugitive monitoring of both existing production and exploration wells.

2 REGULATORY REQUIREMENTS

2.1 Introduction

2.1.1 The Greenhouse Effect

Greenhouse gases (GHG) 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 GHG effect. Water vapour (H_2O), CO_2, nitrous oxide (N_2O), methane (CH_4) and O_3 are the primary greenhouse gases in the earth’s atmosphere. Moreover, there are a number of entirely human-made GHG gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur 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).

2.1.2 IFC Literature on GHG

The International Finance Corporation (IFC) lists methods that countries and projects can reduce GHG impacts. These include carbon financing; improvement of energy efficiency; GHG sinks and reservoir protection and improvements; that environmentally friendly agriculture and forestry be encouraged; the increased use of renewable energy methods; implementation of carbon capture and sequestration methods; and, improved waste management (recovery and use of methane emissions) as well as reducing GHG emissions from vehicle use and industrial, construction and energy production processes (IFC, 2007). Carbon financing may have much potential in developing countries as well as sustainable agriculture and forestry practices (IFC, 2012), and when supported by governments may be a way of reducing the country’s GHG impacts, where projects receive carbon credits and financing for reducing GHG emissions and installing more environmentally friendly alternatives. Because different industries contribute various amounts of GHG emissions, the IFC performance standards suggests that for industrial processes the CO_2-equivalent (CO_2-e) emissions per year do not exceed 100 000 tonnes, this including direct (Scope 1) and indirect (Scope 2) sources (IFC, 2012).

2.1.3 International Agreements

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 end in 2020 (UNFCCC, 2017) but due to lack of ratification has not come into force.

The Paris Agreement was adopted by 196 Parties at Conference of the Parties (COP) 21 in Paris, on 12 December 2015 and commenced 4 November 2016. The Paris Agreement (2016) builds upon the Convention and – for the first time – brings 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 charts a new course in the global climate effort.

The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2°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.

The Paris Agreement is founded on the idea of countries improving on their climate change strategies in 5-year cycles. The Paris Agreement requires all Parties to put forward their best 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.

The Paris Agreement proposes that Parties submit long-term low greenhouse gas emission development strategies (LT-LEDS) by 2020 but this was not mandatory.

Parties will take stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform the preparation of NDCs. There will also be a global stocktake every 5 years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties. Ethiopia submitted their first NDC to the UNFCCC secretariat and ratified the Paris agreement on 9 March 2017. Existing Parties were expected to submit their updated NDC in 2020; and new Parties their original NDCs. Parties are to submit updated NDCs every 5 years. As of May 2021, there are 192 parties that have submitted their NDCs and 8 parties that have submitted their second NDC. There are only 191 Parties to the Paris Agreement; Eritrea has not become a Party to the Paris Agreement but has submitted its first NDC.

Countries as part of the Paris agreement established an enhanced transparency framework (ETF). ETF is to start in 2024 and all countries will need to openly report on all activities untaken and progress in climate change mitigation, adaptation measures as well as any support provided or received. ETF also sets out a procedure for reviewing submitted reports. The information provided as part of the ETF will be used as an input for the global stocktake which will assess the collective progress towards the long-term climate goals.

2.1.4 Global GHG Emission Inventory

The proposed Cluster 2 operations would most likely fall under the category of "energy" for the global GHG inventory. According to the "mitigation of climate change" document as part of the Intergovernmental Panel on Climate Change (IPCC) fifth Assessment Report (AR5) (IPCC, 2014) the 2010 global GHG emissions were 49 (±4.5) Gt CO_2-e, of which 35% (17 Gt CO_2-e) was a result of the energy sector. The World Resources Institute Climate Watch global GHG emissions from the "industrial processes" sector were 2.7711 Gt CO_2-e in 2016 (6% of total anthropogenic GHG emissions).

2.2 South Africa's Status in terms of Climate Change and Quantification of Greenhouse Gases

2.2.1 Paris Agreement - Nationally Determined Contribution

South Africa ratified the UNFCCC in August 1997 and acceded to the Kyoto protocol in 2002, with effect from 2005. However, since South Africa is an Annex 1 country it implies no binding commitment to cap or reduce GHG emissions. The South African Intended Nationally Determined Contribution (INDC) was completed in 2015 and submitted to the UNFCCC[4] on 1 November 2016. This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCC. This document describes South Africa's INDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions.

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

1. Goal 1: Development and implementation of a National Adaption Plan. The implementation of this will also result in the implementation of the National Climate Change Response Plan (NCCRP) per the 2011 policy.
2. Goal 2: In the development of national, sub-national and sector strategy framework, climate concerns must be taken into consideration.
3. Goal 3: An official institutional function for climate change response planning and implementation needs to be assembled.
4. Goal 4: The creation of an early warning, vulnerability, and adaptation monitoring system
5. Goal 5: Develop policy regarding vulnerability assessment and adaptation needs.
6. Goal 6: Disclosure of undertakings and costs with regards to past adaptation strategies.

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

- The approval of 79 (5 243 MW) renewable energy Independent Power Producer (IPP) projects as part of a Renewable Energy Independent Power Producer Procurement Programme (REI4P). An additional 6 300 MW is being deliberated.
- A "Green Climate Fund" has been created to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- It is intended that by 2050 electricity will be decarbonised.
- Carbon Capture and Sequestration (or Carbon Capture and Storage) (CCS).
- To support the use of electric and hybrid electric vehicles.
- Reduction of emissions can be 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; wind power; CCS; and advanced bioenergy.

A draft update of the first NDC was published for public comment[5] on the 30th of March 2021 and the final updated of the first NDC was published and submitted to the UNFCCC[6] on the 27th of September 2021 in preparation for the 26th Conference of the Parties (to held in Glasgow, Scotland in November 2021). The final update of the first NDC South Africa has not submitted its second NDC to UNFCCC. The draft 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.

[4] https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx
[5] https://www.environment.gov.za/mediarelease/creecy_indc2021draftlaunch_climatechangecop26
[6] https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx

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

1. Goal 1: Enhance climate change adaptation governance and legal framework.
2. 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.
3. Goal 3: Implementation of National Climate Change Adaptation Strategy (NCCAS) 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.
4. Goal 4: Mobilise funding for adaptation implementation through multilateral funding mechanisms.
5. Goal 5: Quantification and acknowledgement of the national adaptation and resilience efforts.

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

- The approval of 79 (5 243 MW) renewable energy Independent Power Producer projects as part of a Renewable Energy Independent Power Producer Procurement Programme. An additional 6 300 MW is being deliberated.
- A "Green Climate Fund" has been created to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- It is intended that by 2050 electricity will be decarbonised.
- CCS.
- To support the use of electric and hybrid electric vehicles.
- Reduction of emissions can be 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.
- Updated 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) 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 1.

Table 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

2.2.2 National Climate Change Response Policy

The National Climate Change Response White Paper stated that in responding to climate change, South Africa has two objectives: to manage the inevitable climate change impacts and to contribute to the global effort in stabilising GHG emissions at a level that avoids dangerous anthropogenic interference with the climate system. The White Paper proposes 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 are expected between 2020 and 2025 before a decade long plateau period and subsequent reductions in GHG emissions.

The White Paper also highlighted the co-benefit of reducing GHG emissions by improving air quality and reducing respiratory diseases by reducing ambient particulate matter, ozone and SO_2 concentrations to levels in compliance with NAAQS by 2020.

In order to achieve these objectives, the Department of Forestry, Fisheries and Environment (DFFE) has appointed a service provider to establish a national GHG emissions inventory, which will report through SAAQIS.

The draft Climate Change Bill was published for comment on the 8th of June 2018 and introduced to parliament on the 18th of February 2022 (B9-2022). The Bill is aligned with international policies guidelines and South Africa's Nationally Determined Contribution and aim to reduce GHG emissions as primary driver to anthropogenic climate change. The aim of the Bill is to achieve an effective climate change response through a long-term just transition to a low carbon economy that is climate resilient and allows for sustainable development of South Africa. When in force, the Bill will:

- Establish provincial and municipal forums on climate change which will be responsible for coordinating climate change response actions in each province.
- Strengthen the establishment of the Presidential Climate Change Coordinating Commission (4PC). Although, the 4PC has already been established and has been working for the Government since December 2020, however, its establishment only carries legal force after the Bill becomes an Act.
- Within one year of the coming into force of the Act, establish a National Adaptation Strategy. This strategy will guide South Africa's adaptation to the impacts of climate change and develop adaptation scenarios which anticipate the likely impacts over the short, medium, and long term.
- Determine a national GHG emissions trajectory, which must be reviewed every five years, and which indicates an emissions reduction objective.
- Put in place a 5-yearly sectoral emission targets for identified sectors and sub-sectors. The sectoral targets must be aligned with the national GHG emissions trajectory and include quantitative and qualitative GHG emission reduction goals.
- Bring into force the carbon budget allocation mechanism, which will replace the current National Pollution Prevention Plan mechanism which is enforced under the National Environmental Management: Air Quality Act (NEM:AQA). The carbon budget will be linked to the Carbon Tax Act, in relation to carbon tax rates which will be charged on emissions above the carbon budget.

The Bill is nearing the end of its parliamentary process having been passed by the National Council of Provinces and been returned to the National Assembly for concurrence. It is likely to be enacted during the operational lifetime of the Tetra4 Cluster 2, if not before.

2.2.3 Greenhouse Gas Emissions Reporting

Regulations pertaining to GHG reporting using the National Atmospheric Emissions Inventory System (NAEIS) were published in 2017 (Republic of South Africa, 2017) (as amended by GN R994, 11 September 2020). The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only.

The South African Greenhouse Gas Emission Reporting System (SAGERS) web-based monitoring and reporting system will be used to collect GHG information in a standard format for comparison and analyses. The system forms part of the national atmospheric emission inventory component of South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP). Tetra4 operations will have to report their GHG emissions to SAGERS since there is no threshold for annual GHG emissions reporting for the Natural Gas producers as per the amended GHG reporting guidelines (GG43712, 7 September 2020).

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 SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Methodological guidelines for quantification of GHG emissions (DFFE, 2022), published in October 2022, have been issued to estimate emissions.

Also, the Carbon Tax Act (No 15 of 2019) (Republic of South Africa, 2019) includes details on the imposition of a tax on the CO_2-e of GHG emissions. Certain production processes indicated in Annexure A of the Declaration of Greenhouse Gases as Priority Pollutants (Republic of South Africa, 2017) with GHG more than 0.1 mega tonnes (Mt) or million metric tonnes, measured as CO_2-e, are required to submit a pollution prevention plan to the Minister for approval.

2.2.4 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 categorised 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 (DEA, 2019). 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 2000 to 2017 National GHG Inventory (https://bit.ly/3kkaCco) was prepared using the 2006 IPCC Guidelines (IPCC, 2006) based on updated sector information and emission estimation techniques. According to the 4th Biennial Update Report to the UNFCCC (DFFE, 2021), the total GHG emissions in 2017 were estimated at approximately 512.66 million metric tonnes CO_2-e (excluding Forestry and Other Land Use [FOLU]). This was a 14.2% increase from the 2000 total GHG emissions (excluding FOLU) and 2.8% decrease from the 2015 total GHG emissions (excluding FOLU). FOLU is estimated to be a net carbon sink which reduces the 2017 GHG emissions to 482.02 million metric tonnes CO_2-e. The estimated GHG emissions (excluding FOLU) for 2017 showed the Industrial Processes and Product Use (IPPU) sector contributed 6.3% to the total GHG emissions (excluding FOLU), which relates to 32.08 million metric tonnes. The estimated CO_2-e emissions (excluding FOLU) for 2017 for the Energy sector is 410.64 million metric tonnes, which is 80% of the total GHG emissions.

2.2.5 Draft National Guideline for Consideration of Climate Change in Development Applications, June 2021

The DFFE has, on 25 June 2021, published a Notice under the NEMA requesting public comment on the *Draft National Guideline for the consideration of climate change implications in applications for environmental authorisation, atmospheric emission licences and waste management licences*.

The Draft National Guideline has been developed to support the inclusion of climate change considerations into the EIA process, and to create a consistent approach for such incorporation, which will help proponents to assess:

- how a proposed development will likely exacerbate climate change;
- the impact of a development on features (natural and built) that are crucial for climate change adaptation and resilience; and
- the sustainability of a development in the context of climate change projection.

The Guideline puts forward "a consistent approach in providing interested and affected parties (e.g. proponents, EAPs and specialists) with the minimum requirements to consider when undertaking a climate change assessment, which forms part of an application for environmental authorisation (EA), an atmospheric emissions licence (AEL) and/or waste management licence (WML)".

One of the impact requirements for a climate change assessment is an estimation of the GHG emissions, direct and indirect (including upstream GHG emissions) that will be released into the atmosphere annually throughout the impact related to the activity.

3 CLIMATE CHANGE BASELINE

3.1 Physical Risks of Climate Change on the Region

In 2017 the South African Weather Service (SAWS) published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections (SAWS, 2017). It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results as a result of the model's physics and accuracy of input data; for this reason, an ensemble of models' projections is used to determine the potential change in near-surface temperatures and rainfall depicted in the CCRA. 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°.

Two trajectories are included based on the four Representative Concentration Pathways (RCPs) 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. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the 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. RCP4.5 is based on the expectation that current interventions will reduce GHG emissions and that it will be sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on no interventions implemented to reduce GHG emissions (then after 2100 the concentration is expected to continue to increase).

3.1.1 RCP4.5 Trajectory

Based on the median, for the region in which the proposed facility and communities are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 1.5°C and 2.0°C for the near future and between 2.0°C and 2.5°C for the far future. The seasonal average temperatures are expected to increase for all seasons, in the same order as the annual average increases, with slightly larger temperature increases in autumn (March to May) and larger increases in spring (September to November). The total annual rainfall is expected to increase by between 5 mm and 10 mm for the near future and decrease by up to 20 mm in the far future. Seasonal rainfall is expected to increase in summer (December to February) up to 30mm in the near- and far future, while other seasons are likely to show decreases between 5 and 10 mm.

3.1.2 RCP8.5 Trajectory

Based on the median, the region in which the proposed facility and communities are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 2.0°C and 2.5°C for the near future and between 5.0°C and 5.5°C for the far future. The seasonal average temperatures are expected to increase for all seasons in similar ranges to the annual average temperature, with higher increases in spring, summer, and autumn. The total annual rainfall change is likely to increase by between 20 and 30 mm, while it is more uncertain for the far future with potential decrease up to 5 mm. Seasonal rainfall changes could see an increase of 5 mm in spring and summer in the near future with decreased up to 10 mm in autumn and winter. In the far future, the seasonal the rainfall changes are similar to the near future, except in summer where increased rainfall could be up to 50 mm.

3.1.2.1 Water Stress and Extreme Events

South Africa is known to be a water stressed country (Kusangaya, Shekede, & Mbengo, 2017), but Welkom/Virginia falls within a low water- stress and depletion zone. It falls in a Low-Medium interannual variability but with a Medium-High seasonal variability, leading to a Medium-High drought risk[7]. Climate change, through elevated temperatures, is likely to increase evaporation rates and decrease water volumes available for dryland and irrigated agriculture (Davis-Reddy & Vincent, 2017). Commercial agriculture (crop and livestock farming) is the predominant agricultural land-use in the vicinity of Welkom and Virginia.

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 & Vincent, 2017):

- with high confidence, that heat wave and warm spell duration are likely to increase while cold extremes are likely to decrease, where up to 80 days above 35°C are projected by the end of the century under the RCP4.5 scenario;
- with medium confidence, that droughts are likely to intensify due to reduced rainfall and/or an increase in evapotranspiration; and
- with low confidence, that heavy rainfall events (more than 20 mm per 24 hours) will increase.

[7] https://www.wri.org/applications/aqueduct/water-risk-atlas/#/?advanced=false&basemap=hydro&indicator=w_awr_def_tot_cat&lat=30&lng=-80&mapMode=view&month=1&opacity=0.5&ponderation=DEF&predefined=false&projection=absolute&scenario=optimistic&scope=baseline&timeScale=annual&year=baseline&zoom=3

4 Impact Assessment: The Project's Carbon Footprint

4.1 Scope 1 GHG Emission Sources

4.1.1 Clearing and Rehabilitation – Carbon Sequestration and Carbon Sink

Accounting for the uptake of carbon by plants, soils and water is referred to as *carbon sequestration* and these sources are commonly referred to as *carbon sinks*. Quantifying the rate of carbon sequestration is however not a trivial task requiring detailed information on the geographical location, climate (specifically temperature and humidity) and species dominance (Ravin & Raine, 2007).

Photosynthesis is the main sequestration process in forests and in soils. Carbon is absorbed as fixed carbon into the roots, trunk, branches, and leaves and during the shedding of leaves, but is emitted – although at a reduced percentage – from foliage and when biomass decays. Several factors also determine the amount of carbon absorbed by trees such as species, size, and age. Mature trees, for example, will absorb more carbon than saplings (Ravin & Raine, 2007).

Aspects required to calculate the carbon stack change in the pool (in tons of carbon per year) include the climate, the type of forest or vegetation removed and the type to be re-introduced, and management measures. Soil type also has different absorption and release ratios that need to be included. "Decomposition of soil organic matter in drained inland grassland" was used to the carbon losses from the cleared areas. It should be noted that carbon losses apply to the replacement of vegetation with built infrastructure, except where temporary clearing activities could have long-term impacts on water resources, including rivers, aquifers, streams, and wetlands, or water infrastructure (for example dams and storm water systems) (Government Gazette No. 44761, Notice 559, 25 June 2021), where in this case, vegetation may recover over the pipeline areas.

The areas to be cleared were accounted for as indicated in Table 2.

Table 2: Tetra4 Cluster 2 land clearance during construction

Construction Activity	Description of Area	Area (m^2) (unit area)	No of units	Total area (m^2)
Land Clearance	Road construction	5 000	1	5 000
	Pipeline construction [(a)]	2 500	139	346 530
	Well construction	900	300	270 000
	Booster station construction	3 600	30	108 000
	Compressor station construction	3 600	3	10 800
	Plant construction	93 979	1	93 979
			Area (m^2)	**834 309**
			Area (ha)	**83.43**

Notes: [(a)] This is a conservative approach since vegetation may recover over the pipeline areas.

4.1.2 Construction fuel combustion

There will be an initial carbon sink loss due to the vegetation removal for the new and expansion Cluster 2 areas. GHG will also be emitted through operating diesel-powered mobile and stationary equipment, as listed in Table 3.

Table 3: Tetra4 Cluster 2 construction fuel combustion

Mobile Diesel Equipment	Total kWh	Stationary Equipment	Total kWh
Plant	11 799 841	Natural gas generator	210 287
Pipeline	854 684		
Wells	1 275 986		
Booster Stations	1 275 986		
Compressor Stations	1 275 986		
Drilling	862 682		

4.1.3 Construction well drilling, testing, and servicing

There will be fugitive emissions (excluding venting and flaring) from gas well drilling, drill stem testing and well completions during construction. Emission factors are provided in Appendix A and emissions are calculated in Gg per 10^3m^3 total production. Gas processing was given as 203 786.67 10^3m^3 and assumed to apply to raw gas feed and gas production.

4.1.4 Operations

The main sources of GHG due to the proposed operations are the mobile (trucking) and stationary equipment (generators) (Table 4), emissions from gas processing (fugitives, flaring and raw CO_2 venting) (calculated in Gg per 10^6m^3 raw gas feed – see Table 5) and emissions from transmission and storage (calculated in Gg/year/km and Gg/year/m³ respectively – see Table 6)

Table 4: Tetra4 Cluster 2 operational phase fuel combustion per year

Road transportation (diesel)	Total tonne-km per year	Stationary Equipment	Total kWh
Trucking	187 091 100 [(a)]	Natural gas generator	36 842 352

Notes: [(a)] Total tonne-km per year = assumed 155 909 tpa trucked over 1 200 km

Table 5: Tetra4 Cluster 2 gas processing during an operational year

Gas processed	Volume (10^3 m^3)
Raw gas processed [(a)]	203 786.67

Notes: [(a)] Latest figures provided

Table 6: Tetra4 Cluster 2 transmission (pipeline fugitives and venting) and storage during an operational year

Gas transmission	Length (km)	Storage per year	Volume (m^3/year)	Product (tpa)	Density (kg/m^3)
Pipeline length	120	Product	232 558.14	100 000 [(a)]	430

Notes: [(a)] Maximum product storage per annum provided as 100 000 tpa; product density 430 kg/m³

4.1.5 Decommissioning

As operations progress, the previously cleared areas that form part of the project will be rehabilitated resulting in a carbon sink gain. Even assuming rehabilitation uses the same indigenous vegetation, the carbon balance will not be completely restored. There may also be potential soil degradation due to stockpiling. However, there is insufficient data at this point to determine the decommissioning GHG emissions. This is likely to be equivalent or less than the construction phase, with the reestablishment of a carbon sink in the revegetation of the site.

4.2 Scope 2 GHG Emissions

Scope 2 GHG emissions apply to consumption of purchased electricity, heat, or steam. Tetra 4 Cluster 2 will make use of ESKOM electricity supply for some operations as listed in Table 7.

Table 7: Tetra4 Cluster 2 ESKOM electricity supply during construction and operations

Project phase	Activity	MW	No of hours/ year	Total MWh
Construction	Gas gathering			
	Plant	0.16	5 278	844
Operations	Gas gathering	9.72	8 322	80 890
	Plant	23.06	8 322	191 905

A summary of the calculated GHG emissions for the construction and operational phases is provided in Table 8 and the emission factors used provided in Appendix A.

Table 8: Tetra4 Cluster 2 Scope 1 and 2 GHG emission summary

Emission summary					
Construction	**Activities**	**CO_2 (as tCO_2-e)**	**CH_4 (as tCO_2-e)**	**N_2O (as tCO_2-e)**	**Total CO_2-e (tonnes/year)**
Scope 1 emissions	Land clearance	509			509
	Off-road mobile equipment	4 627	6	529	5 162
	Generators	42	0.09	0.02	43
	Well drilling	10 716			10 716
	Well testing	14 517			14 517
	Well servicing	1 534			1 534
Total Scope 1 emissions	Land clearance, heavy construction, generators, well drilling, well testing and well servicing	32 479			32 479
Total Scope 2 emissions	Electricity bought from ESKOM	861			861
				Total emissions	**33 341**
Operations	**Activities**	**CO_2 (as tCO_2-e)**	**CH_4 (as tCO_2-e)**	**N_2O (as tCO_2-e)**	**Total CO_2-e (tonnes/year)**
Scope 1 emissions	Road transportation	19 858			19 858
	Generators	7 441	15	4	7 460
	Gas processing (fugitives)	65	4 828		4 893
	Gas processing (flaring)	367	6	2	374
	Gas processing (CO_2 venting)	8 151			8 151
	Gas storage		12		12
	Gas transmission (pipeline fugitives)	2	6 900		6 902
	Gas transmission (pipeline venting)	1	2 760		2 761
Total Scope 1 emissions	Road transportation, gas processing, transmission and storage, generators	50 411			50411
Total Scope 2 emissions	Electricity bought from ESKOM	278 251			278 251
				Total emissions	**328 662**

The total CO_2eq emission rate from the Tetra4 Cluster 2 construction phase is 32 479 tpa (Scope 1) and 861 tpa (Scope 2). For a single operational year, the Scope 1 GHG emissions are 50 411 tpa, with Scope 2 accounting for the largest part at 278 251 tpa.

4.3 Scope 3 GHG Emissions

Scope 3 GHG emissions are listed in Table 9.

Table 9: Tetra4 Cluster 2 GHG Scope 3 emission summary

Scope 3 sector	Activities	Total CO_2-e (tonnes/year)
Total Scope 3 emissions – Transportation	Category 4 – Upstream transportation and distribution	6 498
	Category 6 – Business travel	26
	Category 7 – Employee commuting	2 297
	Category 9 – Downstream transportation and distribution	17 962
Total Scope 3 emissions – Products used	Category 1 – Purchased goods and services	147 442
Total Scope 3 emissions – Use of products	Category 11 – Use of sold products	398 391
Total Scope 3 emissions – Other sources	Category 5 – Generated in operations	14 677
	Total emissions	**587 293**

The main source of scope 3 emissions would be the end use of the LNG. As LNG will be replacing other fuels already in use, there will be a reduction in indirect GHG emissions as shown in Table 10. By using LNG, indirect GHG emissions would be reduced by 85 960 tpa.

Table 10: Tetra4 Cluster 2 GHG scope 3 use of sold products to replace other fuels currently in use

Scope 3 sector	Activities	Total CO_2-e (tonnes/year)
Total Scope 3 emissions – Use of products currently (diesel)	Category 11 – Use of sold products	289 531
Total Scope 3 emissions – Use of products currently (LPG)	Category 11 – Use of sold products	122 476
Total Scope 3 emissions – Use of products currently (HFO)	Category 11 – Use of sold products	72 345
Total Scope 3 emissions – Use of products currently (Total)	**Category 11 – Use of sold products**	**484 352**
Total Scope 3 emissions – Use of products in future	**Category 11 – Use of sold products**	**398 391**
	Total emissions reduction	**85 960**

4.4 The Project's GHG Emissions Impact

4.4.1 Impact on the National Inventory

The operational phase of Tetra4 Cluster 2 will likely result in an increase in Scope 1 & 2 emissions. The annual operational CO_2-e emissions from the Tetra4 Cluster 2 operations would contribute approximately 0.08% to the South African "energy" sector total (410.64 million metric tonnes $CO_{2\text{-e}}$, excluding FOLU) and represent a contribution of 0.064% to the National GHG inventory total (512.66 million metric tonnes $CO_{2\text{-e}}$, excluding FOLU), based on the published 2017 National GHG Inventory (DFFE, 2021) (see Section 2.2.4). The annual CO_2-e emissions from the construction phase would contribute approximately 0.008% to the South African "energy" sector total and represent a contribution of 0.007% to the National GHG inventory total (DFFE, 2021).

4.4.2 Alignment with national policy

Regulations pertaining to GHG reporting using the NAEIS were published in 2017 (Republic of South Africa, 2017) (as amended by GN R994, 11 September 2020) where mandatory reporting guidelines focus on reporting of Scope 1 emissions only. 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 SAAQIS GHG emission factor database. With the operational Scope 1 CO_2-e emissions below 100 000 t/a, Tetra4 does not have to report on SAGERS, calculate its Carbon Tax nor compile a pollution prevention plan (PPP).

4.4.3 Physical Risks of Climate Change on the Project's Construction and Operations

4.4.3.1 Temperature

With the increase in temperature, including heat waves, there is the likelihood of an increase in discomfort, possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Both these have the potential to negatively affect staff process performance and productivity.

From a process point of view, elevated ambient temperatures (up to 45°C) may slightly reduce the fuel requirements needed to meet the generating capacity required. However, water use as a dust control measure during construction, may increase.

4.4.3.2 Rainfall, Water Stress, and Extreme Events

Rainfall decreases in autumn, winter and spring could result in constrained water supply outside of summer months. During drought conditions water supply could decline and intended use of reclaimed water and boreholes/wellpoints should be investigated to secure long-term supplies.

The impact of intense rainfall events on the LNG/LHe Plant cannot be ruled out, where the frequency of intense rainfall events could increase from the long-term baseline. These events could affect production capacity during intense rainfall (unless fully protected from rain and wind), flooding affecting site access, safe operation of equipment, delivery of fuel; collection of compressed gas product, as well as physical damage to infrastructure during high wind speed events associated with intense storms.

4.4.4 Impact Assessment: Potential Effect of Climate Change on the Community

4.4.4.1 Temperature

With the increase in temperature, including heat waves, there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). There is also the possibility of increased evaporation which in conjunction with the decrease in rainfall can result in water shortage. This does not only negatively affect the community's water supply but can reduce the crop yields and affect livestock resulting in compromised food security.

4.4.4.2 Rainfall, Water Stress, and Extreme Events

As discussed above the decrease in rainfall can result in the following effects:

- Reduced water supply of reduced water quality; and,
- A negative impact on food security.

The impact of intense rainfall events on the local communities cannot be ruled out, where the frequency of these event could increase from the long-term baseline. These events could affect road access within the area due to flooding, and physical damage to public and private infrastructure through flooding and high wind speeds.

4.5 Project adaptation and mitigation measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention. Mitigation measures are typically the focus of the energy, transport, and industry sectors (Thambiran & Naidoo, 2017). Adaptation measures focus on the minimising the impact of climate change, especially on vulnerable communities and sectors. Inclusion of the climate change adaptation in business strategic implementation plans is one of the outcomes defined in the Draft National Climate Change Adaptation Strategy (Government Gazette No.42466:644, May 2019).

Additional support infrastructure can reduce the climate change impact on the staff and project, for example the improving thermal and electrical efficiency of buildings to reduce electricity consumption, ensuring adequate water supply for staff and reducing on-site water usage as much as possible. A community development program could be initiated to assist communities near the Tetra4 project site that are vulnerable to climate change impacts, such as thermal and electrically efficient buildings (to minimise electricity needs for heating and cooling), energy efficient stoves (to minimise the use of coal and woody biomass), or small-scale renewable energy innovations suitable for use in homes.

Project specific mitigation measures, may include:

- GHG emissions from vehicles and equipment:
  - Maintain vehicles and machinery in accordance with manufacturers standard specifications; and
  - A leak-detection program to be implemented to reduce product loss.
- GHG emissions from flaring, venting and fugitives:
  - Emissions of GHG should be limited as much as possible to reduce the global impact;
  - Flaring and venting of GHG should be minimised; and
  - Prudent operations and reductions in plant upsets would lead to fewer maintenance, startup, and shutdown events that cause flare and blowdown emissions, with the added benefit of retaining more product.
- GHG from National Grid:
  - The implementation and use of renewable energy such as solar photovoltaic (PV) units to replace/ reduce the reliance on ESKOM electricity would reduce the Tetra4 Cluster 2 GHG emissions significantly since ESKOM's contribution to the operational phase is the main source of GHG emissions; and
  - The use of LNG instead of diesel for generators and other stationary equipment would reduce the Project's GHG footprint further.

5 Impact Significance Rating

The significance of climate change impacts was based on Scope 1, 2 and 3 GHG emissions and assessed according to the methodology provided by EIMS (Appendix A). Since climate change is a global phenomenon, the criterion is not fully applicable to an assessment of the impacts of GHG emissions on climate change. However, the criterion is currently the best tool for the climate change impact analysis.

5.1 Construction

Given the nature of construction activities for the roads/pipeline, wells and booster stations (where the location may vary depending on the gas reserves in the area) the negative climate change impacts are considered to be of **Low** significance without mitigation and **Low** significance with mitigation (Table 11).

Table 11: Significance rating for potential Climate Change impacts due to the construction activities

Impact Name	**Climate Change risk due to Scope 1 & 2 construction**				
Alternative	NA				
Phase	Construction				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	2	1
Extent of Impact	-	-	Reversibility of Impact	5	5
Duration of Impact	1	1	Probability	3	3
Environmental Risk (Pre-mitigation)					-8.0
Mitigation Measures					
As construction will be of limited duration. Develop and implement management programs and procedures.					
Environmental Risk (Post-mitigation)					-7.0
Degree of confidence in impact prediction:					Low
Impact Prioritisation					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.17
Final Significance					-8.17

Note: [a] The extent of climate change impact is always national or wider and therefore can result in an overly conservative significance, and since the overall consequence and significance are not influenced by the extent, but rather by the intensity of emissions, "extent" was not included in the significance rating.

5.2 Operation

Vehicle and trucks, natural gas generators, the processing and flaring of gas, fugitive releases, and indirect upstream and downstream emissions could result in **Medium** significance on climate change and could reduce, although still **Medium** significance with mitigation and adaptation measures in place (Table 12).

Table 12: Significance rating for potential climate change impacts due to the Project operations

Impact Name	Climate Change risk due to the operational phase of the project				
Alternative	NA				
Phase	Operations				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	-	-	Reversibility of Impact	5	5
Duration of Impact	4	4	Probability	3	3
Environmental Risk (Pre-mitigation)					-12.0
Mitigation Measures					
Emissions of GHG should be limited as much as possible to reduce the global impact. Flaring and venting of GHG should be minimised. A leak-detection program to be implemented to reduce product loss. Replacing ESKOM electricity supply with renewable energy. Using LNG instead of diesel in equipment and machinery.					
Environmental Risk (Post-mitigation)					-11.0
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Cumulative Impacts					3
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.33
Final Significance					-14.67

Note: [a] The extent of climate change impact is always national or wider and therefore can result in an overly conservative significance, and since the overall consequence and significance are not influenced by the extent, but rather by the intensity of emissions, "extent" was not included in the significance rating.

5.3 Alternative Significance Rating

Other literature (Murphy & Gillam, 2013) suggests use of thresholds (Table 13) presented as tonnes of CO_2e per year, as basis for specific consideration of the specific elements to be assessed in the EIA, as guidance states that the contribution of an individual project to climate change cannot be measured.

Table 13: GHG and Climate in EIA – Elements to consider

GHG emissions (tonnes CO_2e/year)	Qualitative rating	Elements of assessment to consider
GHGs < 25 000	Very Low	Quantify GHG
25 000 < GHGs < 100 000	Low	Look at possible mitigation, quantify GHG, place in context
100 000 < GHGs < 1 000 000	Medium	As above and prepare management plan, describe existing climate conditions, consider how changes in climate may affect project and surroundings
GHGs > 1 000 000	High	As above and consider adaptation analyses

Based on the suggested thresholds from Table 13, the construction phase Scope1 GHG emissions would result in **Low** significance, and Scope 2 **Very Low**, with a combined significance of **Low**. The operational phase would result in **Low** significance for Scope 1 emissions, and **Medium** for Scope 2 emissions, where the combined (Scope 1 and Scope 2) significance would be **Medium**. The contribution of Scope 3 to GHG emissions would result in a **Medium** significance.

6 CONCLUSION

The region around Welkom and Virginia where Tetra4 Cluster 2 project is proposed to be developed is likely to experience increased temperatures and extreme weather-related events in the future. Climate change impacts will disproportionately affect under-developed communities that lack the physical and financial resources to cope with the physical effects of climate change, such as droughts, floods and increases in diseases.

Scope- 1, 2 and 3 emissions were estimated based on emission factors and expected production rates or raw material use. The main construction activities attributing to GHG emissions are well drilling, well testing and well servicing followed by off-road mobile equipment. During operations, the electricity bought from ESKOM (Scope 2) is the main source, followed by road transportation and gas process venting (Scope 1). The main source of Scope 3 GHG emissions would be the end use of the LNG, but as LNG will be replacing other fuels already in use, it will result in a reduction of 14.6% in indirect GHG emissions.

Construction- and operational-related GHG emissions from the proposed Tetra4 Cluster 2 project cannot be attributed directly to any particular climate change effects, and, when considered in isolation, will have a Low to Medium impact on the National GHG inventory total. The main GHG impact is associated with downstream use of the LNG, i.e. Scope 3. GHG emissions per unit of gas combusted, however, is less than per unit coal.

Climate change is a global challenge and there is a collective responsibility to address the global challenge of climate change and Tetra4 has an individual responsibility to minimise its own negative contribution to the issue. It is therefore recommended that:

- Renewable energy (such as PV Solar) be considered to replace/ reduce the reliance on ESKOM electricity – this is likely to reduce the significance from the Tetra4 Cluster 2 project from Medium to Low, since ESKOM's contribution to the operational phase is the main source of GHG emissions.
- Also, the use of LNG instead of diesel will reduce the GHG footprint further.
- Maintenance of vehicles and machinery, the implementation of a leak-detection program, and the minimisation of flaring and venting would reduce the potential for GHG emissions.

Once operational, it is recommended records be kept of actual fuel usage for transport of materials and products, energy requirements, production rates, flare and venting rates and raw material consumption for GHG reporting purposes and refinement of the emissions inventory.

Based on Tetra4 Cluster 2 Scope 1, 2 and 3 GHG emissions, it is the specialist opinion that the project may be authorised due to its low to medium impact significance.

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8 APPENDIX A – EMISSION FACTORS

IPCC Category	Description	Emission source	Fuel/material	Emission factors			Unit	Source	Notes
				CO_2	CH_4	N_2O			
	Scope 1 - Direct Emissions								
1.A.3.e.ii	Mobile combustion	Off-road mobile equipment	Diesel	74100	4.15	28.6	kg per TJ	2006 IPCC default	
1.A.3.b		Road transportation	Diesel	0.10614			kg CO_2e per tonne.km	2022 UK DEFRA	All HGVs. Average laden. Assumed 155 909 tpa trucked 1 200 km.
1.A.4.a	Stationary combustion	Generator	Diesel	74100	3	0.6	kg per TJ	2006 IPCC default	
			Natural gas	56100	1	0.1	kg per TJ	2006 IPCC default	
1.B.2.b.ii	Natural gas flaring and venting	Well drilling	Natural gas	1E-04	0.000033	ND	Gg/10³ m³ total gas production	SA 2022 Methodological guidelines for quantification of GHG emissions	Provided gas processing 203 786 67 m³.
		Well testing	Natural gas	9E-03	5.1E-05	6.8E-08	Gg/10³ m³ total gas production		
		Well servicing	Natural gas	1.9E-06	1.1E-04	ND	Gg/10³ m³ total gas production		
1.B.2.b.iii.3	Gas processing	Fugitives	Gas	1.5E-04 to 3.2E-04	4.8E-04 to 1.03E-03	NA	Gg/10⁶ m³ raw gas feed	SA 2022 Methodological guidelines for quantification of GHG emissions	Sweet gas plants. Assumed raw gas feed 203 786 67 m³.
1.B.2.b.ii		Flaring	Gas	1.8E-03	1.2E-06	2.5E-08	Gg/10⁶ m³ raw gas feed		
1.B.2.b.i		Raw CO_2 venting	Gas	0.04	NA	NA	Gg/10⁶ m³ raw gas feed		Default. Assumed raw gas feed 203 786 67 m³.
1.B.2.b.iii.4	Gas transmission and storage	Transmission - fugitives	Gas	1.6E-05	2.5E-03	n/a	Gg/year/km	SA 2022 Methodological guidelines for quantification of GHG emissions	Assume 120 km.
1.B.2.b.i		Transmission - venting	Gas	8.5E-06	1E-03		Gg/year/km		
1.B.2.b.iii.4		Storage	Gas		2.32E-09		Gg/year/m³		Assumed storage of 100 000 tonne.
3.B.3.b	Decomposition of soil organic matter in drained inland grassland	Land clearance	Grassland	6.1	n/a	n/a	tonnes CO_2-C/ha/yr	1996 & 2006 IPCC default	

IPCC Category	Description	Emission source	Fuel/material	Emission factors			Unit	Source	Notes
				CO_2	CH_4	N_2O			
	Scope 2 - Indirect Emissions								
	ESKOM energy grid	Electricity generation	Coal	1.02	n/a	n/a	tonnes CO_2 per MWh	Median value from Eskom Integrated Reports (2016-2021)	
	Scope 3 - Indirect Emissions								
	Transportation	Category 4 - Upstream transportation and distribution	Plant, pipeline and overhead line goods.	0.10614			kg CO_2e per tonne.km	2022 UK DEFRA	All HGVs. Average laden. Assumed 125 540 tonne/year trucked from (450 km)
			Well casing goods.	0.10614			kg CO_2e per tonne.km	2022 UK DEFRA	All HGVs. Average laden. Assumed 10 500 tonne/year trucked from (450 km)
		Category 6 - Business travel	Air	0.18362			kg CO_2e per passenger.km	2022 UK DEFRA	International. Average passenger. Assumed 14 400 km (USA) – 2 trips, 3 people. Assumed 9 500 km (Europe) – 2 trips, 3 people.
		Category 7 - Employee commuting	Car petrol	0.17048			kg CO_2e per km	2022 UK DEFRA	Average car. Assumed 58 people 60km/day.
			Car diesel	0.170824			kg CO_2e per km	2022 UK DEFRA	Average car. Assumed 35 60km/day.
			Taxi	0.02136			kg CO_2e per passenger.km	Toyota Quantum specifications	299g CO_{2e}/km, assumed 14 passengers. Assumed 246 people 60km/day.
			Bus	0.0965			kg CO_2e per passenger.km	2022 UK DEFRA	Average local bus. Assumed 915 people 60km/day.

IPCC Category	Description	Emission source	Fuel/materia l	Emission factors			Unit	Source	Notes
				CO_2	CH_4	N_2O			
		Category 9 - Downstream transportation and distribution	He	0.10614			kg CO_2e per tonne.km	2022 UK DEFRA	All HGVs. Average laden. Assumed He trucked to Durban (600 km).
			He	0.003539			kg CO_2e per tonne.km	2022 UK DEFRA	Cargo ship. Average bulk carrier. Assumed He shipped to Asia, Europe and USA (14 461 km average).
			LNG	0.011548			kg CO_2e per tonne.km	2022 UK DEFRA	Sea tanker. Assumed 445 tonne/day produced, 350 days/year. Assumed % 60 LNG shipped to China (16 433 km).
	Products used	Category 1 – Purchased goods and services	Concrete	131.751			kg CO_2e per tonne	2022 UK DEFRA	Assumed tonne/year concrete: 5 940 (wells) + 95 040 (plant, pipeline and overhead line).
			Metal	4018.003			kg CO_2e per tonne	2022 UK DEFRA	Assumed tonne/year metal: 4 560 (wells) + 21 500 (plant, pipeline and overhead line).
			HDPE	3269.839			kg CO_2e per tonne	2022 UK DEFRA	Assumed tonne/year HDPE: 9 000 (pipeline).
	Use of products	Category 11 –	LNG	2559.17			kg CO_2e per tonne	2022 UK DEFRA	Assumed 445 tonne/day

IPCC Category	Description	Emission source	Fuel/materia l	Emission factors			Unit	Source	Notes
				CO_2	CH_4	N_2O			
		Use of sold products							produced, 350 days/year.
	Other sources	Category 5 - Waste generated n operations	Waste	467.0084			kg CO_2e per tonne	2022 UK DEFRA	Industrial waste. Landfill. Assumed 31 428 tonne/year waste.
	Conversion Factors								
	Global Warming Potential (GWP) (100 year time horizon)			1	23	296	tonne CO_2e/tonne	Annexure G (DFFE, 2022)	

9 APPENDIX B – IMPACT SIGNIFICANCE RATING METHODOLOGY

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations (2010). 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. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, 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).

Determination of Environmental Risk:

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:

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

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 14.

Table 14: 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
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).

Aspect	Score	Definition
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 (Table 16). Probability is rated/scored as per Table 15.

Table 15: 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 x P

Table 16: 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 17.

Table 17: 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:

In accordance with the requirements of Regulation 31 (2)(l) of the EIA Regulations (GNR 543), and 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.

In addition, it is important that the public opinion and sentiment regarding a prospective development and consequent potential impacts is considered in the decision-making process.

In an effort 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 18: 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 18. The impact priority is therefore determined as follows:

$$\textbf{Priority = PR + CI + LR}$$

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (refer to Table 19).

Table 19: Determination of prioritisation factor

Priority	Ranking	Prioritisation Factor
3	Low	1
4	Medium	1.17
5	Medium	1.33
6	Medium	1.5
7	Medium	1.67
8	Medium	1.83
9	High	2

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring (Table 20). The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table 20: Final environmental significance rating

Environmental Significance Rating	
Value	**Description**
< 10	Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
≥10 <20	Medium (i.e. where the impact could influence the decision to develop in the area),
≥ 20	High (i.e. where the impact must have an influence on the decision process to develop in the area).