APPENDIX L: CLOSURE AND REHABILITATION PLAN

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FINAL REHABILITATION, DECOMMISSIONING AND CLOSURE PLAN, INCORPORATING AN ANNUAL REHABILITATION PLAN AND ENVIRONMENTAL RISK ASSESSMENT FOR THE RHINO OIL AND GAS EXPLORATION SOUTH AFRICA (Pty) LTD UPDATED EXPLORATION WORK PROGRAMME FOR VARIOUS FARMS IN THE FREE STATE PROVINCE (12/3/318 ER)

Version – final

April 2023

GCS Project Number: 23-0244

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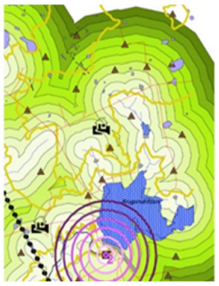


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	Name	**Signature**	**Date**
Author	Magnus van Rooyen		April 2023
Director	Magnus van Rooyen		April 2023

SPECIALIST DECLARATION

I, Magnus van Rooyen, in my capacity as a specialist consultant, hereby declare that I –

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act (Act No. 107 of 1998);
- Have and will not have vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act (Act No. 107 of 1998);
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member;
- Based on information provided to me by the project proponent and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability; and
- Reserve the right to modify aspects pertaining to the present investigation should additional information become available through ongoing research and/or further work in this field.

Magnus van Rooyen (Pr.Sci.Nat) April 2023
SACNASP reg. no. 400335/11 Date

CONTENTS PAGE

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

FINAL REHABILITATION, DECOMMISSIONING AND CLOSURE PLAN, INCORPORATING AN ANNUAL REHABILITATION PLAN AND ENVIRONMENTAL RISK ASSESSMENT FOR THE RHINO UPDATED EXPLORATION WORK PROGRAMME FOR VARIOUS FARMS IN THE FREE STATE PROVINCE (12/3/318 ER)

1 INTRODUCTION

GCS Water and Environment (Pty) Ltd has been appointed by SLR Consulting (South Africa) (Pty) Ltd on behalf of Rhino Oil and Gas Exploration South Africa (Pty) Ltd (Rhino) for the preparation of a final rehabilitation, decommissioning and closure plan for Rhino's updated exploration work programme (EWP), inclusive of well drilling within their Exploration Right (ER) on various farms in the Free State Province (12/3/318 ER). This document also makes provision for an annual rehabilitation plan and an environmental risk assessment.

2 DETAILS OF THE SPECIALIST

Mr van Rooyen holds a Masters degree in Environmental Management, he also holds a BSc degree in Botany and Zoology, an Honors degree in Botany and a Post Graduate Certificate in Education. He has in excess of 20 years' experience in the environmental consulting field through conducting and managing Environmental Impact Assessments, Specialist Terrestrial and Aquatic Ecology Assessments and Strategic Environmental Management inputs into various project feasibility studies.

Through these services, he has been exposed to projects in a range of sectors which include the general public infrastructure sector (national and provincial roads, harbour and rail developments, water (dams and supply) and wastewater (treatment works and reticulation), private infrastructure sector (small and large scale housing developments, lodges, private dams, etc.), agricultural sector (dams, establishment of orchards, plantations and feedlots), mining sector (coal mines, gold mine, manganese mines, aggregates and associated mining infrastructure) and the industrial sector (light and heavy industrial infrastructure development).

He is professionally registered with the South African Council for Natural Scientific Professions (Registration No. 400335/11).

3 FINAL REHABILITATION, DECOMMISSIONING AND MINE CLOSURE PLAN

In accordance with the Financial Provisioning Regulations, 2015 Government Notice R1147 the objective of the final rehabilitation, decommissioning and closure plan must be to identify the following:

- Post-exploration land use that is feasible through provision of a vision, objectives and criteria for final rehabilitation, decommissioning and closure of the project;
- Outline of the final design principles for closure;
- Methodology for the risk assessment and link closure activities to the risk rehabilitation;
- Provide closure action to indicate the measures that will be taken to mitigate and/or manage identified risks and describe the nature of residual risks that will require long term monitoring and management post-closure;
- Provide a schedule, budget, roles and responsibilities for final rehabilitation and decommissioning and closure of each relevant activity (or infrastructure component);
- Identify any knowledge gaps as well as provision for measures to address these;
- Detailing the full closure cost for the duration of the project at increasing levels of accuracy as the project develops and approaches closure in relation to the final land use proposed; and
- Outline of the monitoring, auditing and reporting requirements for the duration of the process.

4 PROJECT DESCRIPTION

4.1 Introduction

Rhino intends to continue their exploration activities in ER 318 and has made application to renew the ER for a further two (2) year duration and to update the EWP. The proposed addition to the EWP is for the drilling of several exploration wells to test for the presence, quantity and quality of gas within specific Target Areas within the current ER area. As part of the updated EWP, Rhino are proposing to drill a total of up to 40 wells.

4.2 Location

The details associated with the project location is consistent with the information contained in the Scoping Report (SLR, 2022) that was accepted by the relevant authority.

The extent of ER 318 includes ~ 3 000 properties (farms and portions) over an area of approximately 600 000ha (see regional setting in Figure 3-1).

Rhino has identified three (3) Target Areas within which the updated well drilling EWP intends to focus. The Target Areas include:

- **Target Area 1** is approximately 200 km^2 in extent and is located approximately 4 km west of Allanridge and 5 km north of Welkom. The Target Area includes ~ 680 properties;
- **Target Area 2** is approximately 450 km^2, approximately 4 km northeast of Allanridge and 20 km west of Kroonstad. The Target Area includes ~ 324 properties;
- **Target Area 3** is approximately 138 km^2 in extent in the eastern portion of ER 318, with Steynsrus located 38 km south and Kroonstad to 2 km west. The target Area includes ~ 228 properties.

Given the large number of properties included, it is not feasible to include a cadastral description of every property in this document.

The location of the proposed 40 well drilling sites is subject to a process of geological review, landowner consent and environmental and social risk consideration. Areas that are unsuitable are eliminated from further consideration. As described in the EIA Report (SLR, 2023), Rhino identified 15 potential well sites through a screening process. Deployment of any of the 25 'unseen well' sites would be subject to compliance with the Environmental Management Programme (EMPr) (SLR, 2023) which includes, amongst other, adhering to the environmental constraints used to identify the initial 15 'identified well' sites.

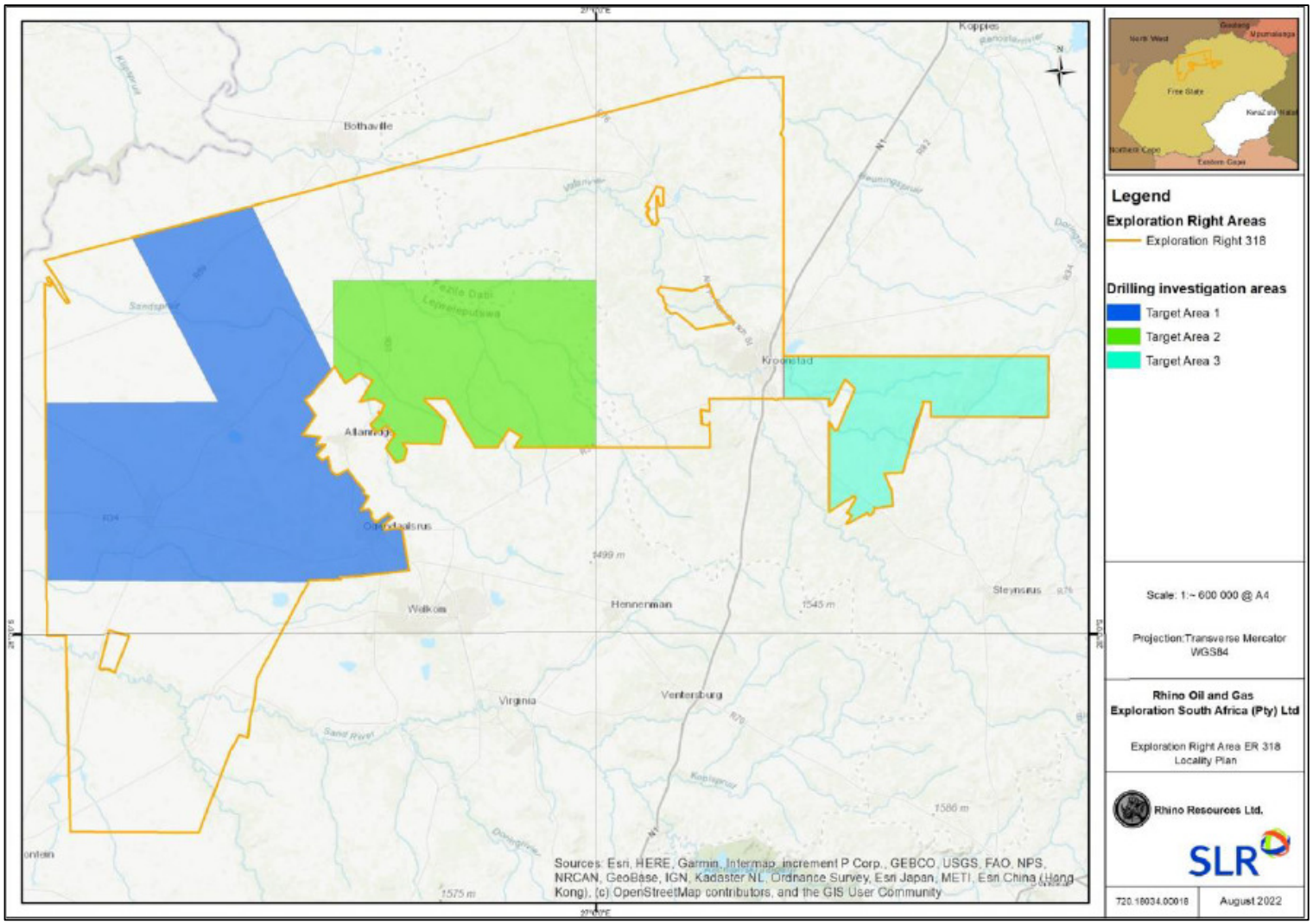

Figure 4-1: Location and extent of the Exploration Right Area as well as the specific Target Areas (SLR, 2022)

4.3 Exploration program and scheduling

The Drilling Program and Time Schedule proposed by Rhino is to start drilling at least five exploration wells within the ER in 2023.

If any of the first ten exploration wells result in the identification of commercially viable commodities (hydrocarbons, helium, or hydrogen), Rhino's Drilling Program and Project Schedule would be updated to include the drilling of additional exploration wells at different locations within the Target Areas.

Completed exploration wells will be tested to evaluate their commerciality, as described further in this chapter. The drilling of the exploration wells will likely be undertaken as one or two campaigns. At the end of operations, unsuccessful wells will be plugged and abandoned ("decommissioned"). Successful wells will have their ability to produce preserved but be capped and secured for possible future field development (subject to a receipt of the requisite approvals including, amongst others, Environmental Authorisation by means of a separate EIA process for Production Rights (PR)).

The drilling time to complete one well is estimated to take approximately 3 to 4 weeks. The results of the first few wells drilled within the Target Areas will influence the positioning and pace of the rest of the drilling campaign based on the interpretation of the geological, geophysical, fluid sampling data. The sequencing of the drilling campaign will be dynamic and influenced by the learnings of each new well.

4.4 Exploration drilling activities

Activities associated with the exploration drilling include the following phases:

- Mobilisation;
- Well drilling:
- Well execution (redrill, logging, completion) options;
- Well testing for successful well options;
- Well abandonment for unsuccessful well (plug and abandonment "decommissioning"); and
- Demobilisation of the drill rig, supply truck and local logistics base.

4.4.1 Mobilisation phase

The drilling locations will be identified prior to mobilisation of the drill rig based on the results of the analysis of airborne geophysical data, regional geological analysis, historical data integration, landowner consultation and environmental sensitivities.

During mobilisation, the drill rig and supporting equipment will arrive directly on location from previous jobs (probably from Renergen drill sites) or from Rhino's drilling contractor main yard near Pretoria.

Once on location, the well site will be prepared by drilling contractor. A typical drill site schematic is provided as Plate 4-1. Should any obstacles/sensitivities be identified at the drilling location, the well will be relocated to a nearby location where no obstacles/sensitivities are located.

These activities will be followed up with safety checks, drills, communication tests. This will take approximately 2 to 4 days to complete.

Plate 4-1: View of typical drill rig that will be used in the exploration activities

4.4.2 Drilling phase

The drilling sequence for the exploration drilling campaign is not yet defined as it will depend on the first exploration well results. However, it is currently planned that each Target Area will have at least 1 well drilled in the initial 10 exploration wells campaign.

To evaluate and confirm the commercial viability of the reservoir, a vertical or slanted well will be drilled to a total depth of approximately 1 000 m below surface. The expected valuable fluid for these wells is biogenic gas, helium or geological hydrogen. A standard well design and programme for onshore wells is described below. This will be updated after the completion of seismic interpretation and stratigraphy evaluation by the geologists and petroleum engineers. The final well path will be defined according to the reservoir target and final location of the wellhead at surface. Rhino's preference for drilling exploration wells is a slanted well profile allowing maximum chance to intersect naturally occurring faults in the basement rocks.

During the drilling phase, different drilling bit sizes are used to drill a series of telescoping holes, from the surface to the total depth of the planned well. The first hole, the outer diameter, is the biggest and called the top hole, while the next inner holes are progressively smaller and smaller as the well depth increases. This continues until the final hole, which is the smallest, reaches the reservoir level. Further details regarding the section diameters, depths and planned profile of the well are provided in Figure 4-3.

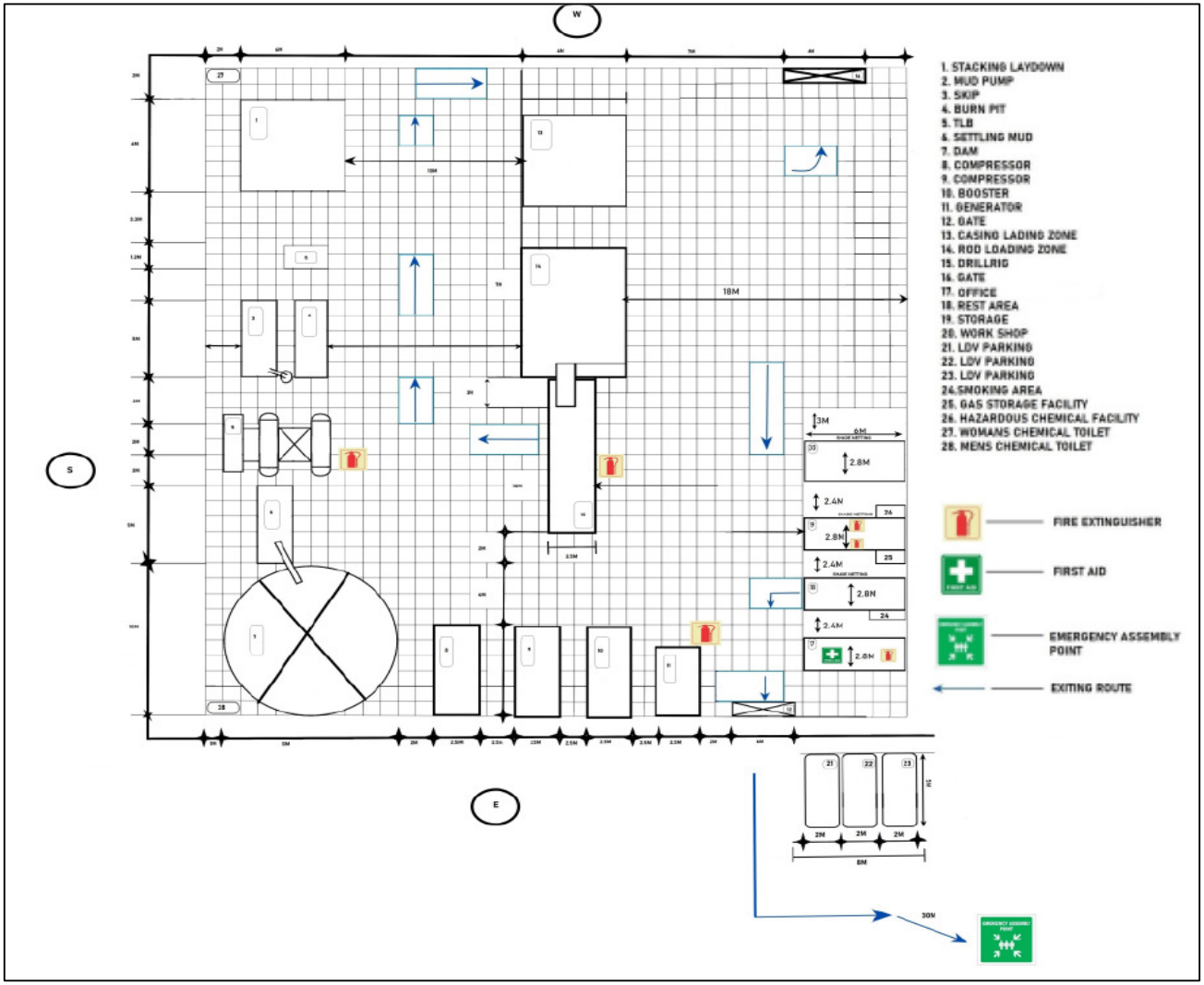

Figure 4-2: Drill site layout (source Torque Africa)

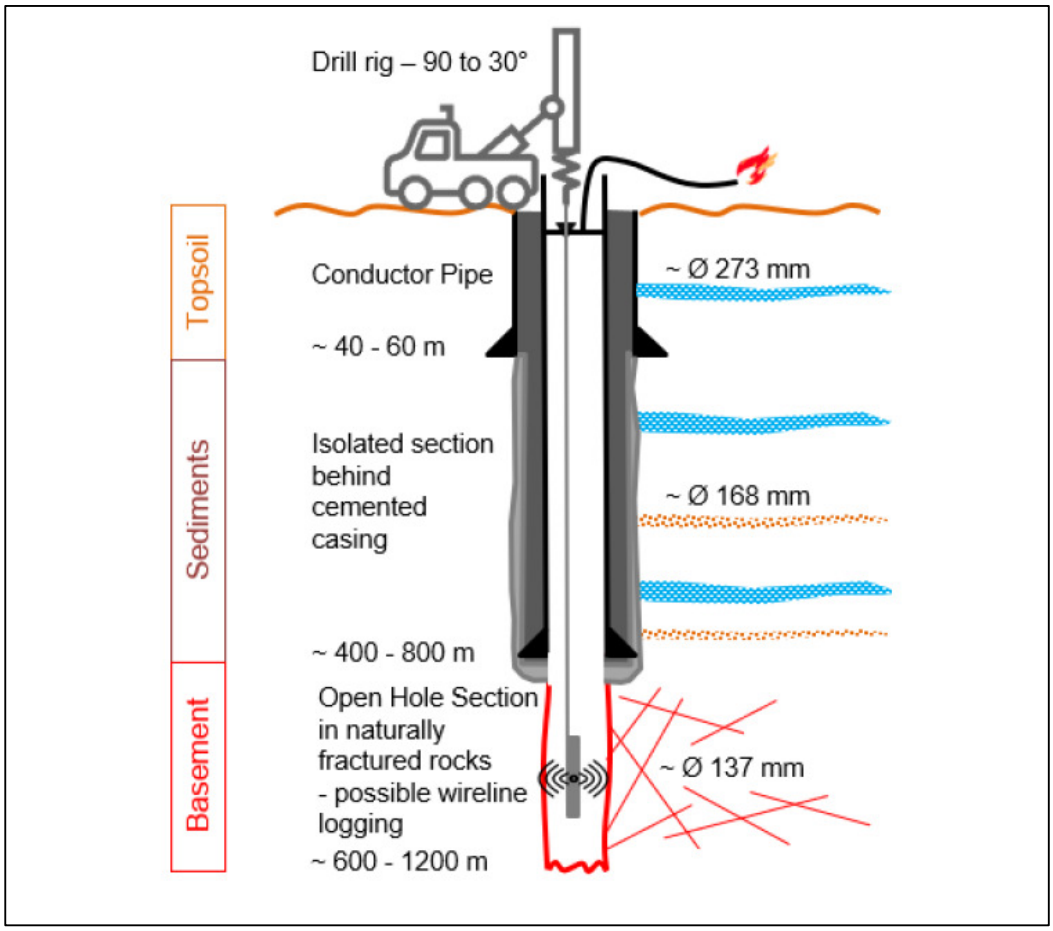

Figure 4-3: Typical well schematic at the end of the drilling phase (source ROGESA, 2022)

During the drilling process, drilling fluids such as compressed air or muds are pumped down the inside of the drill pipe and exit at the drill bit to optimise drilling operations. For the first section (top hole) of the well, a conductor pipe will be installed at the same time as the hole is dug out down to around 50 m to isolate from any ground water. In the bottom sections of the well, air drilling (i.e., with compressed air injected) will be mainly carried out. The water-based mud programme will only be deployed if high rock formation pressure encountered. The main functions of drilling fluids (air or mud) include the following:

- Removal of drilled rock cuttings from the bottom of the well and from the well bore and transportation of these cuttings to the surface;
- Control of formation pressures and managing of formation fluids (i.e., 'primary well control');
- Transmission of power to the drill bit;
- Provision of hydrostatic pressure as well as chemical stability to the rock to maintain the integrity of the hole and prevent hole collapse;

- Lubrication and cooling of the drill bit.

The drill bit is connected to surface by a string of hollow tubulars referred to as the drill string. On the rig floor, drill pipes are attached, one by one, to the top of the string as the drill bit advances into the borehole. The action of drilling (creating a hole in the rocks stratigraphy) is obtained by applying weight and percussion to the bit. The top drive, installed in the truck mounted drill rig, advances the drill string into the well, and provides the rotation/percussion and weight on bit required to drill. The drill string goes through a Rotating Control Device (RCD) to provide physical barrier with wellbore and allow flow back diversion to flare in case of hydrocarbon intersection. Once each hole section has been drilled, casing (steel tubulars) is run into the well and cemented in place to secure/seal the hole interval just drilled and to allow for the drilling of the next (smaller) hole section. The cement operation consists of pumping cement down the drill string to the bottom. The cement flows, out the bottom of the casing shoe and back up into the annular space around the casing, sealing the space between the cased tube and open hole.

Casing plus cement is a tested barrier that facilitates the drilling of the next section, allowing to reach the target final depth in the safest way. During the drilling stage, fluid (mainly air) and dust/cuttings are discharged directly on the surface in immediate proximity of the well after going through a cyclone separator. The physical and chemical properties of the drilling fluid are constantly monitored and adjusted to suit varying down-hole conditions. These conditions are, in part, due to the variation in formation pressure within the well bore at different depths. If water-based mud is in use, fluid density (or mud weight) is adjusted with mud additives. The three main mud additives likely to be used by the drilling contractor are AMC EzeeMix (classified non-hazardous), AMC Aerofoam and AMC Rotafoam (classified non- to moderate-hazardous). The mud additives details can be found on AMC website (**www.amcmud.com**).

4.4.3 Well execution options

In case of any issues related to stratigraphy (e.g., permeable zones with different pressure gradient, hole instability, necessity to increase the inclination of the well to achieve the reservoir target) or problem during the drilling activities (e.g. bottom hole assembly stuck) it would be easier to **redrill** the well in a nearby location. The initial open hole will be cemented up and abandoned.

Different sensors are used throughout the drilling operation to measure several parameters such as quality of cement job, lithology, fluid types.

A dedicated run to **measure/log** the cement bond and consistency in the annuli is performed at the end of each cement job, prior to start drilling operations in the next phase.

Further detailed information is obtained on the physical properties of the rock formations and fluids (water, oil, gas) by means of an open and cased hole logging using sensors introduced down- hole with a wireline cable, or coiled tubing unit.

This operation is usually performed at the end of the drilling phase, after the bottom hole final clean up.

The logging plan is developed in accordance with standard industry best practices. In the case of unsuccessful wells, once a full log of the reservoir section might have been undertaken, the well will be plugged and abandoned. The completion phase, if confirmed in case of discovery, will be performed.

Well completion and well testing operations will be conducted during drilling of successful exploration wells. The completion phase of a successful well takes place after the reservoir formation has been drilled and maintained open hole.

At the beginning of the completion operations, the wellbore is displaced with an industrial water, necessary to balance the downhole pressure and, at the same time, to complete the removal of dust/mud/solids from the well in order to minimise any potential damage to the rock formation.

The selection of salt and brine composition will be defined once the hydrocarbon has been discovered in the exploration well and reservoir lithology completely logged although simple industrial water is expected to be adequate considering low pressure encountered in regional analog exploration or production wells.

The successful well will be capped with well head valve connected to metering equipment with a flare stack at the end of it.

4.4.4 Well testing for successful well options

As stated previously, well testing may be conducted on the successful wells if they present potential commercial quantities of hydrocarbon. A well test is a temporary completion of a well to acquire dynamic rate through time, pressure, and fluid property data. The well test often indicates how the well will perform when it is subjected to various flow conditions. An analysis is usually performed on the data to determine reservoir parameters and characteristics including pressure, volume, and temperature. Current testing practices are carried out using modern testing equipment and high-resolution pressure data acquisition system, getting the reservoir evaluation objectives depends on the behavior of the formation fluid properties, well completion, and flow assurance situations are only known when testing is carried out.

The well test objectives are to:

1. Determine key technical factors of the reservoir (e.g., size, permeability and fluid characteristics) and values for use in future drilling.
2. Obtain representative data including reservoir pressure, production rates and sample(s).

While testing, hydrocarbons are sent to a flare boom with a burner to ensure as complete combustion of fluids (including hydrocarbons) as possible. To ensure that burning can be done safely from the drill site, a flare pit can be installed in order to prevent fire propagation.

The flow periods and rates will be limited to the minimum necessary to obtain the required reservoir information during the well test. It is anticipated that a maximum well test time for this project will be approximately 30 days.

Downhole sampling, if required, normally consists of recovering reservoir fluids via wireline or through specific tools added directly to the temporary test string. Wireline testing involves running instruments into the borehole on a cable to measure formation pressures and obtain fluid samples. Formation fluids are brought to the surface where the composition can then be analysed.

The following key well testing preventative measures will be implemented during the well testing programme:

- Monitor flare performance to maximise efficiency of flaring operations;
- Flare equipment appropriately inspected, certified and function tested prior to operations;
- Flare equipment appropriately maintained and monitored throughout well testing operations; and
- The appropriate emergency stop mechanisms (Emergency Shut Down devices) are in place to halt testing in case of emergency.

4.4.5 Well control and blow-out prevention

Health, safety and environmental protection are prioritised throughout the drilling process. There is a specific focus and attention during preparation and operations to avoid any potential accidental events, with related hydrocarbon release or uncontrolled flow from downhole to surface.

Well control during well operations is a routine function, with each well designed and executed to minimise risk of developing a well control incident. Down-hole conditions, such as shallow gas and high-pressure zones can cause control measures as a sudden variation in well pressure. A well kick can occur if there is an influx of formation fluids with sufficient pressure to displace the well fluids.

The drilling will be done through a Rotative Control Device (RCD) that creates a pressure tight barrier against drilling hazards and allows safe diversion to the side flare stack (Figure 4-4). RCD must be pressure rated to the expected pressure to be encountered in the regional subsurface conditions.

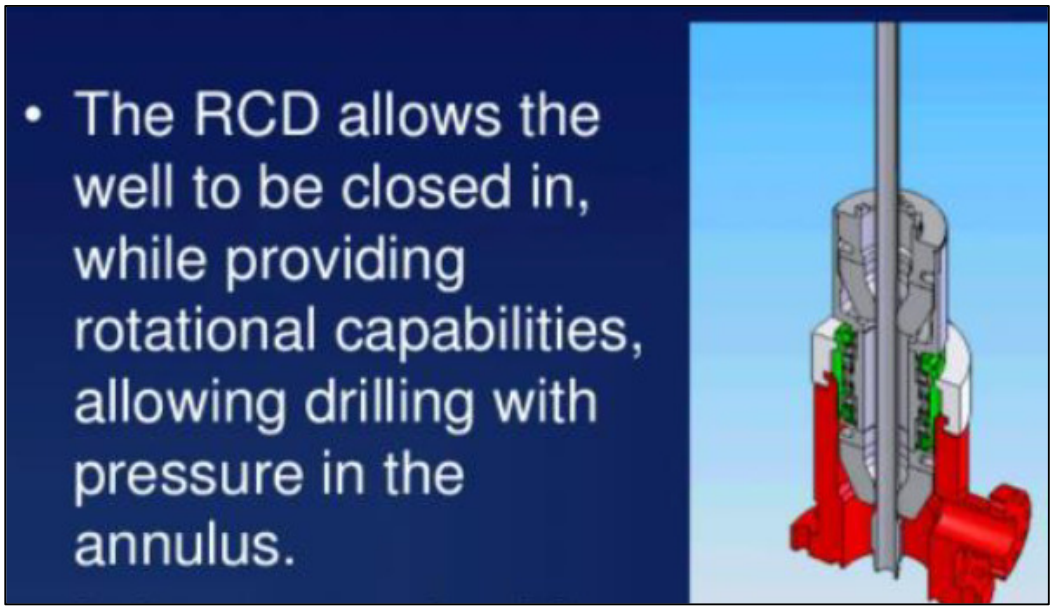

Figure 4-4: Rotating control device (source, Slideshare.net/SPE)

4.4.6 Well abandonment (plug and abandonment "decommissioning")

Once drilling is completed, an unsuccessful well will be plugged and abandoned. The scope of well abandonment is to protect the environment by effectively sealing off all distinct permeable zones (i.e., the zones of potential hydrocarbons or water inflow penetrated by the well), to ensure that formation fluids are isolated, both within the wellbore and in annular spaces, and that their migration among different formations and/or up to the surface is prevented.

For unsuccessful wells, a cement plug setting job will be performed (Figure 4-5). The plugging and abandonment job will be final, in that no re-entry of the well is planned. The cement plugs are suitable to guarantee the effectiveness and integrity of the seal and are configured so that no future intervention and monitoring is required.

In the presence of a single permeable zone, the well will be isolated by means of at least one well barrier (plug). When the formation pore pressure from a permeable zone is expected to exceed the formation fracture pressure anywhere else in the open hole, two well barriers shall be present in order to prevent formation breakdown or underground blowout.

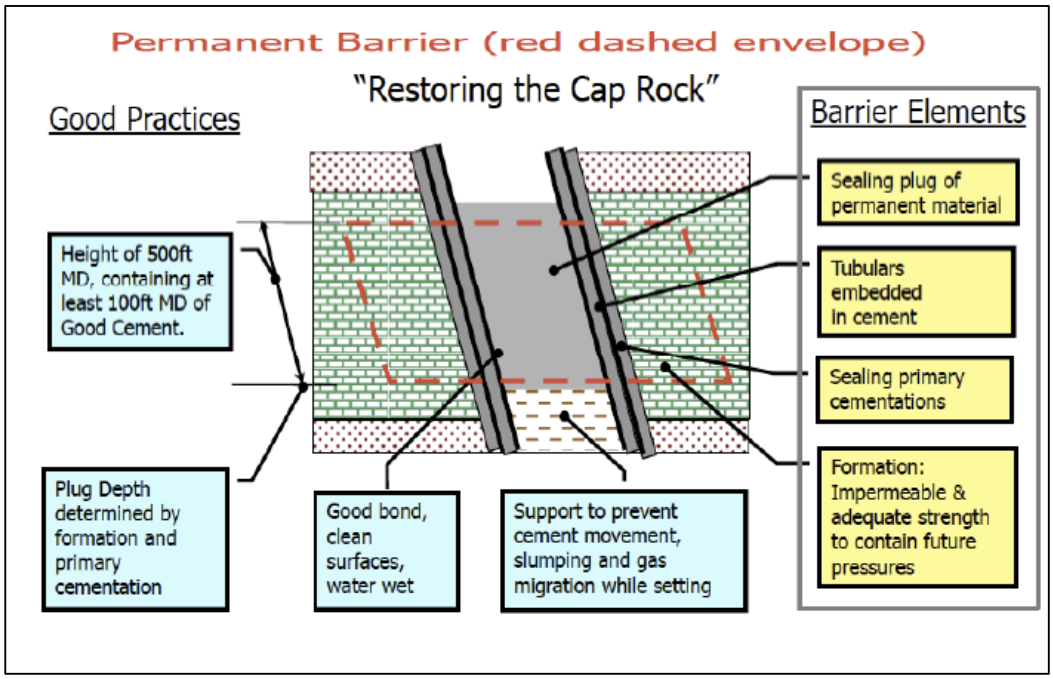

Figure 4-5: Schematic of cement plug at the bottom of a well (Soure: Guidelines for the abandonment of Wells, OGUK, 2015)

For each distinct permeable zone, two well barriers, referred to as “primary” and “secondary”, shall be present in order to prevent also cross flow to surface or vice versa. As per industry best practice, the primary well barrier envelope will have a well barrier element set across or above the highest point of potential influx (top permeable zone or top perforations) or as close as reasonably possible to it. The secondary well barrier shall have a well barrier element set in such a way to guarantee the sealing of the permeable zone in case of failure of the first well barrier.

The RCD will be then retrieved, and the wellbore will be flanged capped.

The final program for well plugging and abandonment will be finalized after the end of drilling phase and log evaluation, in order to properly design the number and composition of plugs sealing in the single or multiple permeable zones discovered.

At the end of the plug and abandonment operations, the well schematic and wellhead location (including casings dimension, length, cement plug dimension and composition, pressure and inflow test results etc.) will be included in a final report submitted to PASA and registered on the Title Deed of the property it is located on.

4.4.7 Demobilisation

On completion of drilling, the drill rig and support trucks will leave the wellsite location. A final well site verification survey will be performed to check the condition of the wellsite.

5 ENVIRONMENTAL AND SOCIAL CONTEXT

This section aims to provide the general information on the relevant environmental (geographical, physical, biological, social, economic, heritage and cultural) aspects associated with the proposed activities in the Well Drilling Target Areas within ER 318 area. The section therefore identifies the environmental sensitivities associated with the proposed exploration activities at a high-level, based on currently available information.

This description is based on the baseline information provided in the Scoping Report associated with the project and is based on several sources which included the following:

- Provincial Biodiversity Conservation Plans;
- Data held by the South African National Biodiversity Institute (SANBI), World Wildlife Fund (WWF), BirdLife SA, Animal Demography Unit (ADU) and provincial conservation bodies etc;
- National Freshwater Priority Areas project;
- The International Union for the Conservation of Nature (IUCN) Red Data List of species;
- Available internet information on environmental issues related to exploration and production;
- Mining and Biodiversity Guideline;
- Available internet information on the baseline environment within the Well Drilling ER application area;
- Topocadastral and geological maps covering the Well Drilling ER application area at scales ranging from 1:50 000 to 1:250 000;
- Previous reports undertaken by SLR for the project area; and
- Municipality Integrated Development Plans and/or Municipality Spatial Development Frameworks.

Where appropriate, more detailed information is provided in the EIA Report (SLR, 2023).

5.1 Cultural Heritage/Paleontological resources

Heritage (and cultural) resources include all human-made phenomena and intangible products that are the result of the human mind. Natural, technological or industrial features may also be part of heritage resources as places that have made an outstanding contribution to the cultures, traditions and lifestyles of the people or groups of people of South Africa.

The Well Drilling Target Areas are likely to include numerous heritage sites that are documented in the national and provincial heritage databases as well as many undiscovered sites. Each of the various towns associated with the Target Areas are likely to have buildings and graveyards of heritage significance. Many farms within the area will have graves and cemeteries while buildings of heritage significance are also likely on the older farms.

According to the SAHRIS database the Target Areas are located in a region that is generally regarded as having a very high to moderate palaeontological sensitivity. It follows that there is a high likelihood of fossil occurrence within most of the ER application area. More detailed information will be provided in the EIA report, following the Heritage Study.

5.2 Socio-economic

This section describes the socio-economic conditions of the area.

5.2.1 Districts

The Well Drilling Target Areas are largely located within three Local Municipalities in the Free State Province, namely:

- Nala Local Municipality;
- Moqhaka Local Municipality; and
- Matjhabeng Local Municipality.

Details (predominately based on Census 2011 data) pertaining to the three local municipalities area are provided in the section below. The Well Drilling Target Areas also has a small overlap with the Ngwathe (in the northeast corner) and Tswelopele (in the southwest corner) Local Municipalities. However, due to the limited overlap, these are not discussed in detail.

5.2.2 Population

The population of the Nala Local Municipality has decreased 3.3% from 81 220 in 2011 to 78 515 persons in 2016. The population of the Moqhaka Local Municipality has decreased by 4.4% from 167 892 in 2001 to 160 532 persons in 2011. The community survey conducted during 2016 indicated that the population once again decreased with 3.61% to 154 732.

The Matjhabeng Local Municipality experienced a 5.14% growth rate from 407 020 to 429 113 between 2011 to 2016.

5.2.3 Employment

In the Nala Local Municipality, there are 26 611 economically active (employed or unemployed but looking for work) people, and of these 35.9% are unemployed. Of the 12 357 economically active youth (15–35 years) in the area, 47.6% are unemployed.

Within the Moqhaka Local Municipality, there are 55 594 economically active (employed or unemployed but looking for work) people, and of these 35.2% are unemployed. Of the 27 349 economically active youth (15–34 years) in the area, 47.2% are unemployed.

In the Matjhabeng Local Municipality, A total of 99 650 people are employed while 13 290 are discouraged work-seekers. According to Census 2011, 58 524 people are unemployed, making the unemployment rate stand at 37%. Of the youth aged 15–34, 39 442 are employed and 38 975 are unemployed.

5.2.4 Households

In the Nala Local Municipality, there are 21 703 households in the municipality, with an average household size of 3.7 persons per household. 40.4% of households have access to piped water either in their dwelling or in the yard. Only 1.2% of households do not have access to piped water.

Within the Moqhaka Local Municipality, there are 45 661 households, with an average household size of 3.2 persons per household. 57.7% of households have access to piped water either in their dwelling or in the yard. Only 1% of households do not have access to piped water.

There are 123 195 households in the Matjhabeng Local Municipality, with an average household size of 3.1 persons per household. Of those households, 36% have access to piped water inside the yard whereas 54.8% have access to piped water inside their dwelling. Only 2% of the households do not have access to piped water.

5.2.5 Basic services

The percentage of the total population located within each of the local municipalities within the Well Drilling Target Areas that have access to drinking water, sanitation and power is included in Table 5-1. Where access to sanitation is not available, alternative sources include pit toilets, bucket system, chemical toilets and other. Where access to power is not available, alternative sources such as wood, gas and paraffin are used.

Table 5-1: Demographics – Basic services (Source: StatsSA, Census 2011 data)

Local municipality	Access to drinking water	Access to sanitation	Access to power
Nala Local Municipality	87.6%	97.3%	Lighting: 90.4% Heating: 54.3% Cooking: 85.6%
Moghaka Local Municipality	87.2%	98%	Lighting: 93.3% Heating: 65%
Matjhabeng Local Municipality	95%	97.4%	Lighting: 91.1%

5.2.6 Education

Education information for each of the local municipalities located within the Well Drilling Target Areas is included in Table 5-2 below.

Table 5-2: Demographics – Education (Source: StatsSA, Census 2011 data)

Local municipality	No education	Completed grade 12	Higher education
Nala Local Municipality	7.9%	22.2%	5.6%
Moghaka Local Municipality	5.3%	27.8%	8.6%
Matjhabeng Local Municipality	4.6%	28%	9%

5.3 Geology and topography

This section describes the geological and topographical nature of the Well Drilling Target Areas.

5.3.1 Regional geology

The proposed Well Drilling Target Areas lies in the north east of the Karoo Basin (see Figure 6-1). The main Karoo Basin in South Africa formed as a result of compression predominantly associated with flexural subsidence, characteristic of foreland basins, during the assembly of the Gondwana super-continent. Consensus on the tectonic setting of the basin, however, remains debated (Tankard et al., 2012; Schreiber-Enslin et al., 2014). The Karoo Basin represents a diverse and complex suite of rock units with an aerial extent of roughly 600 000 square kilometres that attains a maximum sedimentary thickness of 12 kilometres. The north east of the basin is host to several distinct facies of rocks that vary between shore face, fluvial and lacustrine sediments, deposited between the Permian and Triassic.

The deposition of Karoo Supergroup sediments ended in the early Jurassic during the emplacement of the igneous rocks that constitute the Drakensberg Group. The preserved basalts and dolerites attain a maximum thickness of approximately 1 400 m in the Lesotho area. The northern flank of the basin is defined by the erosional limits of the late Carboniferous-Permian Dwyka and Ecca Groups, where they unconformably overlay Archean-Cambrian age, Kaapvaal and Namaqua-Natal basement. The Ecca Supergroup consists mainly of sandstone and shale from the Permian period. The Dwyka Formation within the proposed Well Drilling ER application area consists mainly of tillite from the Carboniferous period.

5.3.2 Resource assessment

Resource assessments of the Karoo Basin have historically emphasised the world-class coal reserves that have dominated the energy history of South Africa. Some limited onshore exploration for hydrocarbon occurrences was undertaken in the 1960s, but no commercial hydrocarbon occurrences were discovered. However, it is expected that the north-east Karoo Basin has potential for a tremendous diversity of hydrocarbon resources including helium and biogenic gas.

One of the complications recognised during the initial resource exploration effort undertaken in the 1960s was the widespread occurrence of dolerite dykes, especially in the north-east Karoo Basin. The thermal effects of these dykes led some early researchers to state that the dykes were required for distillation of hydrocarbons from adjacent coal and shale beds. The complexity of these dyke intrusions, well documented in the shallow north-east Karoo coal fields, makes it difficult to understand the geometry of any possible reservoir horizons in the adjacent sediments. As a result, there is poor understanding of the relationship between the observed non-commercial oil and gas occurrences and any structural control. Further compounding the perception of an absence of commercial hydrocarbons in the Karoo Basin was the documentation of low-permeability conditions in most drill holes. This led many researchers to conclude that the rocks possessed too low a permeability to produce hydrocarbons and porosities too low to trap them.

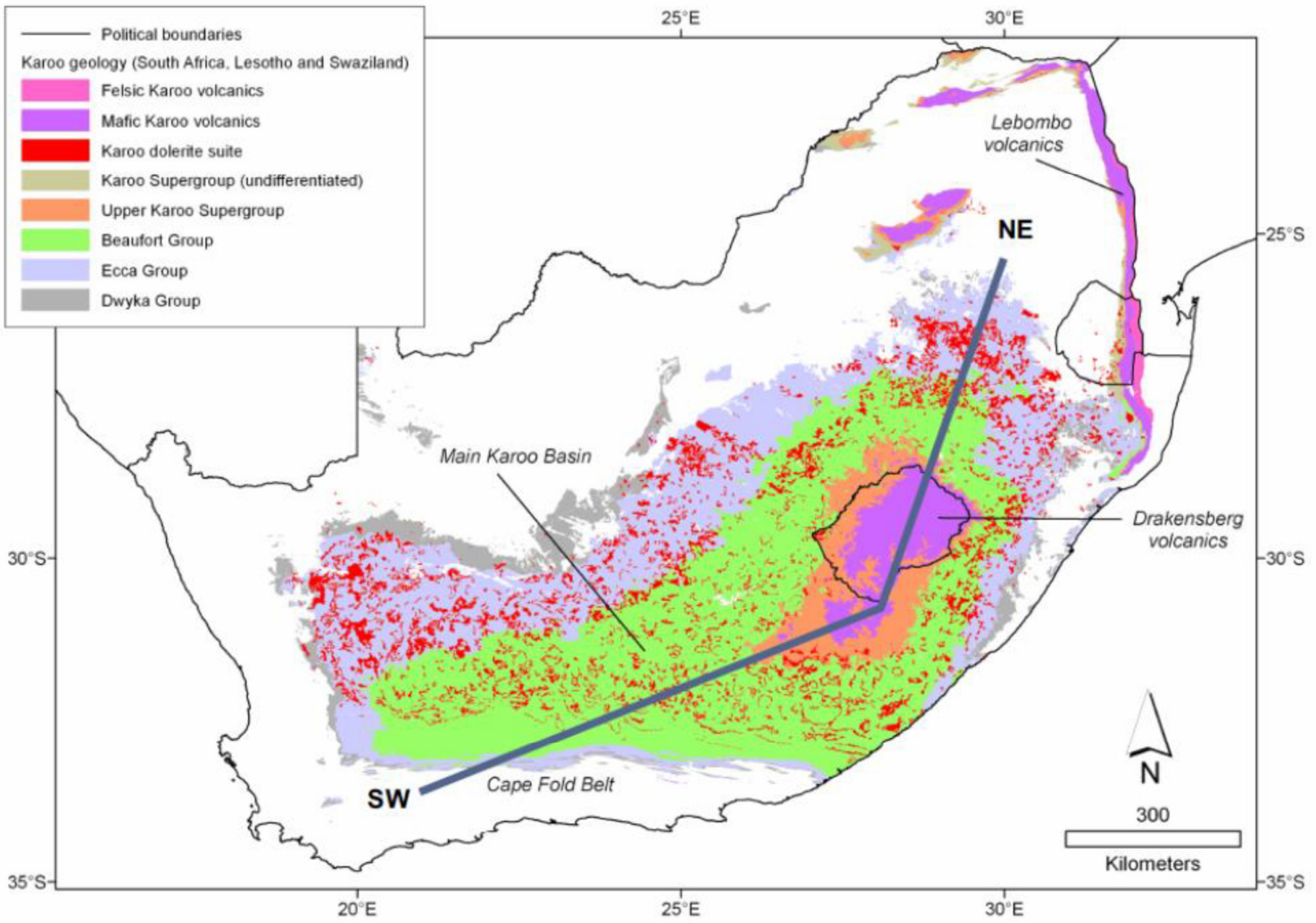

Figure 5-1: Simplified geology of the Karroo Basin (Source: PRASA Brochure)

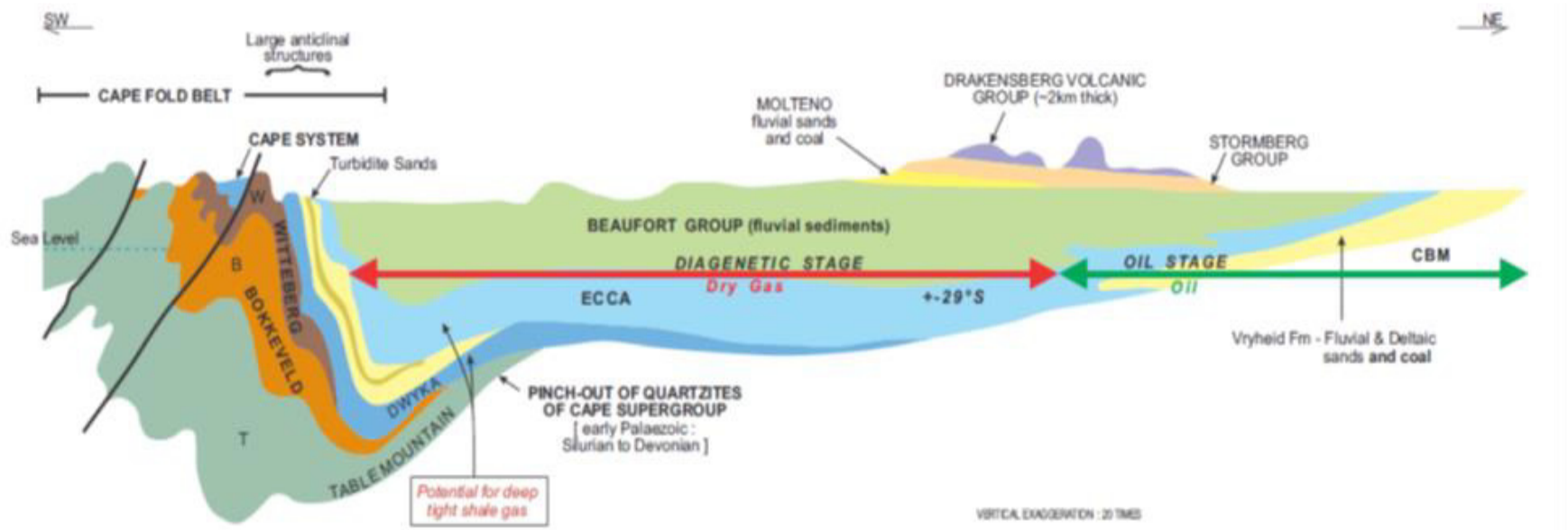

Figure 5-2: Section through the Karroo Basin (Source: PRASA Brochure)

5.3.3 Seismicity

The Southern African region is considered to be relatively stable from a seismic perspective. South Africa is located on the African tectonic plate, which includes the African continent and parts of the floor of the Atlantic and Indian Oceans. In general earth tremors and quakes are infrequent and generally of low magnitude. The largest ever recorded earthquake to occur in South Africa was the Ceres-Tulbagh Earthquake, which occurred in September 1969, and had a magnitude of 6.3 on the Richter Scale.

There are areas in South Africa with higher peak ground acceleration which indicates a greater likelihood of earthquakes. These are found in the Western Cape region and in parts of the northern and western Free State, as well as the Witwatersrand. In general, the Well Drilling Target Areas are not located in a region with high levels of seismicity although minor earth tremors have been recorded in the recent past.

5.4 Climate

Rainfall across the Well Drilling Target Areas is limited to the summer months and is mostly in the form of thunderstorms.

Regional Mean Annual Precipitation (MAP) can vary between 544 mm to 668 mm per annum. Day temperatures reach a maximum of up to 28℃ in the months of January and December (the hottest months of the year), whilst the lowest night temperatures can drop to a minimum of -5℃.

The wettest six months of the year are between October and March, with maximum precipitation occurring in December at an average of 112 mm and approximately 19.5 days of precipitation. On average 10 days of frost are experienced in the winter month of July, which is also the driest month of the year (Source: https://www.meteoblue.com/).

5.5 Soils and land capability

Soils across the Well Drilling Target Areas are extremely diverse with soils ranging in structure and composition. The majority of soils within the study area are considered Lithic and Duplex and to lesser degree Oxidic. Lithic soils are young soils with orthic topsoil but weakly developed subsoil. Oxidic and Duplex soils both have orthic topsoils and are soils with a special subsoil relating to their pedogenic accumulation. Other less common or in lesser concentration soils include Cumulic and Gleyic soils.

Land capability of the region is largely tied to topography (slope), rainfall and altitude. Regions with steeper gradients and higher altitudes generally have lower agricultural potential.

5.6 Land use and cover

Land cover across large parts of the region comprises natural rangeland. The majority of the ER area consists of grassland (see Figure 5-3). Cultivated areas are evident across the region, except in the areas of high altitude and steep slope.

5.6.1 Agricultural activities

The ER area is home to significant commercial agriculture. Agricultural activities associated with the area include a combination of crop production, animal production, horticulture, dairy farming, game farming, aquaculture, fruit production and agro-processing. Major crops are maize, soybeans, wheat, sorghum, sunflowers, potatoes, groundnuts and wool. Much is dryland but there are areas of irrigated crops. The main vegetable is asparagus, both of the green and white varieties. The large majority of the land is used for extensive livestock grazing (cattle and sheep). Subsistence farming is mostly associated with the towns where residents run livestock on the townlands

5.6.2 Main towns

The main towns located within the Well Drilling Target Areas include the following:

- Kroonstad;
- Wesselsbron; and
- Odendaalsrus.

These towns comprise numerous buildings such as schools, sports facilities, hospitals/clinics, shops, local farm co-operations and designated residential areas.

5.7 Air quality

The majority of the proposed Well Drilling Target Areas is rural in nature and is comprised mostly of small towns, isolated farmsteads, scattered communities and agricultural activities such as livestock grazing and crop cultivation. It follows that the air quality associated with majority of the area is expected to be good. The quality of air within and near to major towns is expected to be reduced due to various factors such as vehicle emissions and industrial operations. Existing emission sources within the Well Drilling Target Areas include fugitive dust from paved and unpaved roads, wind erosion from open areas, household fuel combustion (fuel and coal), vehicle exhaust emissions and smoke from veld fires in winter and stack emissions from industries.

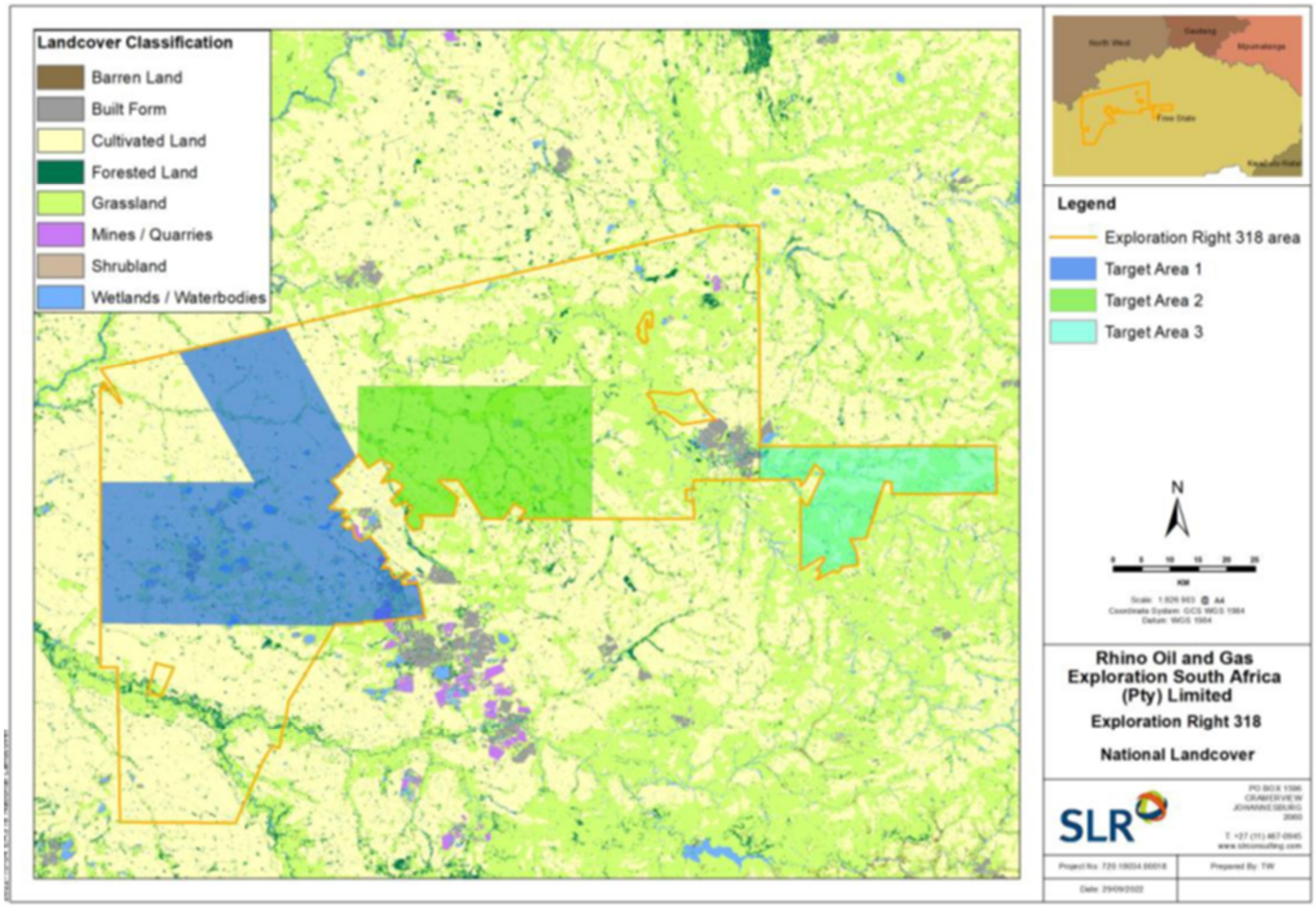

Figure 5-3: National land cover database (2020)

5.7.1 Local road network

Numerous tarred provincial roads are located within the ER area. These include the following:

- The R76 from Kroonstad to Viljoenskroon;
- The R30 from Bothaville to Odendaalsrus and Welkom; and
- The R719 between Bultfontein and Wesselsbron.

That national tarred road (N1) also traverses a portion of the ER area connecting Kroonstad to Johannesburg. Further to this, numerous gravel roads are located within the Target Areas predominately associated with access to farms.

5.7.2 Existing Mineral Rights

Rhino will shortly submit a request to the Regional office of the DMRE for information on properties on which there are existing prospecting or mining rights (for non-petroleum minerals), and/or for which applications for prospecting or mining rights have been submitted. If there are overlapping rights Rhino will engage with the holders prior to the undertaking of any well drilling.

5.7.3 Land Claims

Rhino will shortly submit a request to the provincial office of the Commission on Restitution of Land Rights for information on properties with the Well Drilling Target Areas on which there are existing Land Claims.

5.7.4 Core Astronomy Areas

To date no Core or Central Astronomy Advantage Areas have been declared within the Well Drilling Target Areas.

5.8 Groundwater

5.8.1 Aquifer classification

The Well Drilling Target Areas are located within an area classified as a minor aquifer region, which implies a moderately yielding aquifer system of variable water quality in terms of the Aquifer Classification Map of South Africa. Certain parts of the Well Drilling Target Areas are classified as poor aquifer regions, which implies a low to negligible yielding aquifer system with moderate to poor water quality. Although borehole yields in the deeper aquifer are generally, considered low, structural features such as faults and fractures can produce higher yielding boreholes.

Aquifer vulnerability indicates the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer. In terms of the Well Drilling Target Areas, the aquifer vulnerability in accordance with the Aquifer Vulnerability Map of South Africa (Conrad et al. 1999c), varies between 'least' and 'moderate' vulnerability. The areas of 'least' vulnerability are areas that are only vulnerable to conservative pollutants in the long term when continuously discharged or leached. The areas of 'moderate' vulnerability are areas which are vulnerable to some pollutants, but only when continuously discharged or leached.

Aquifer susceptibility indicates the qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification. In terms of the Aquifer Susceptibility Map of South Africa (Conrad et al, 1999b), the Well Drilling Target Areas is associated with a 'low' to 'medium' susceptibility aquifer.

5.8.2 Groundwater quality

The Groundwater Quality Map of South Africa (Conrad et al, 1999b) indicates that the groundwater quality that can be expected within the Well Drilling Target Areas has electrical conductivity concentrations from low (0 – 70 mS/m) to 150 – 370 mS/m where the water will have a noticeable salty taste.

5.8.3 Groundwater use

There is significant groundwater use at a local scale with many farmers dependent on the abstraction of groundwater for both potable water as well as for stock watering and in some cases irrigation.

5.9 Hydrology

This section deals with the hydrological features of the area.

5.9.1 Catchments and river systems

The Well Drilling Target Areas falls within the Middle Vaal Water Management Area (WMA). The Vaal River is the only main river in the Middle Vaal WMA. It flows in a westerly direction from the Upper Vaal water management area, to be joined by the Skoonspruit, Rhenoster, Vals and Vet Rivers as main tributaries from the Middle Vaal water management area, before flowing into the Lower Vaal water management area and then into the Orange River. The Middle Vaal WMA covers a catchment area of approximately 44 803 km^2. The total water requirements in the Middle Vaal WMA are 872 million m^3/annum.

The Middle Vaal WMA consists of numerous quaternary catchments. The characteristics of the quaternary catchments located within the Well Drilling Target Areas are included in Table 5-3 below. Figure 5-4 illustrates the distribution of the quaternary catchments within the Well Drilling Target Areas.

Table 5-3: Quaternary catchment characteristics (SLR, 2015)

Water management area (WMA)	Quaternary catchment	Mean annual runoff (mcm)	Catchment area (km^2)
Middle Vaal WMA	C25B	9.4	1 888
	C25C	6.6	1 210
	C27f	8.1	2 219
	C43A	6.0	1 491
	C43B	3.3	723
	C60F	17.87	659
	C60D	16.66	645
	C60C	28.63	1 048
	C60G	16.4	782
	C60H	4.2	1 232
	C70H	3.99	251
	C70K	10.9	

5.9.2 Major dams

The Vaal River is located within the ER and is one of South Africa's strongest-flowing rivers (see Figure 5-5). The Vaal Dam itself falls outside of the ER. Several other small dams and numerous farm dams are located within the proposed Well Drilling ER area, which are largely used for livestock and domestic purposes.

5.10 Wetlands

Based on the National Freshwater Ecosystem Priority (NFEPA) wetland database (2011) the Target Areas include a significant number of wetlands ranging in hydrogeomorphic classification, including:

- Channelled valley-bottom wetlands;
- Depressions;
- Flat;
- Floodplain wetlands;
- Seep;
- Unchannelled valley-bottom wetlands; and
- Valleyhead seeps.

For reference, the location of the NFEPA wetlands within the Target Areas are illustrated in Figure 5-6.

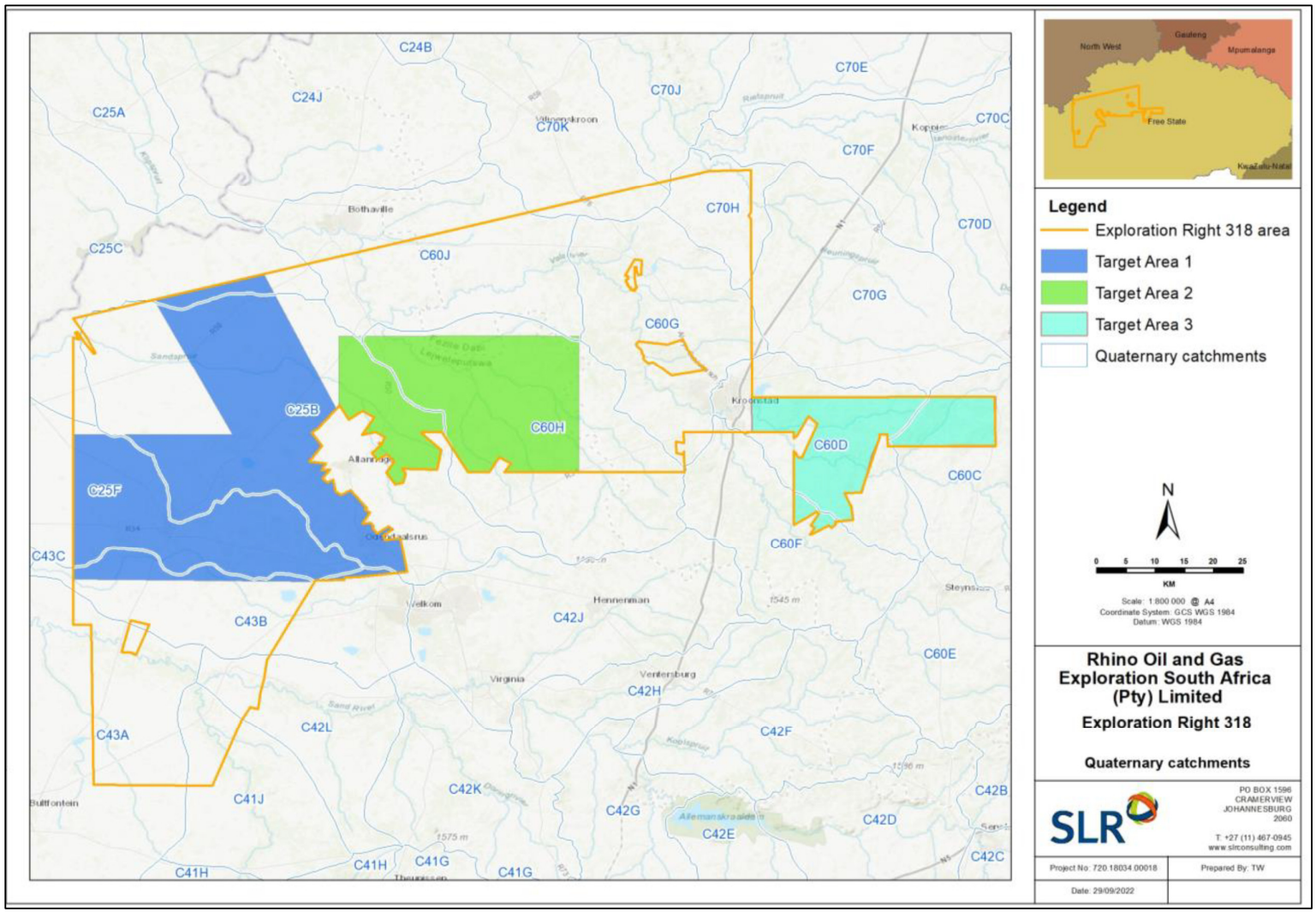

Figure 5-4: Water management areas and catchments

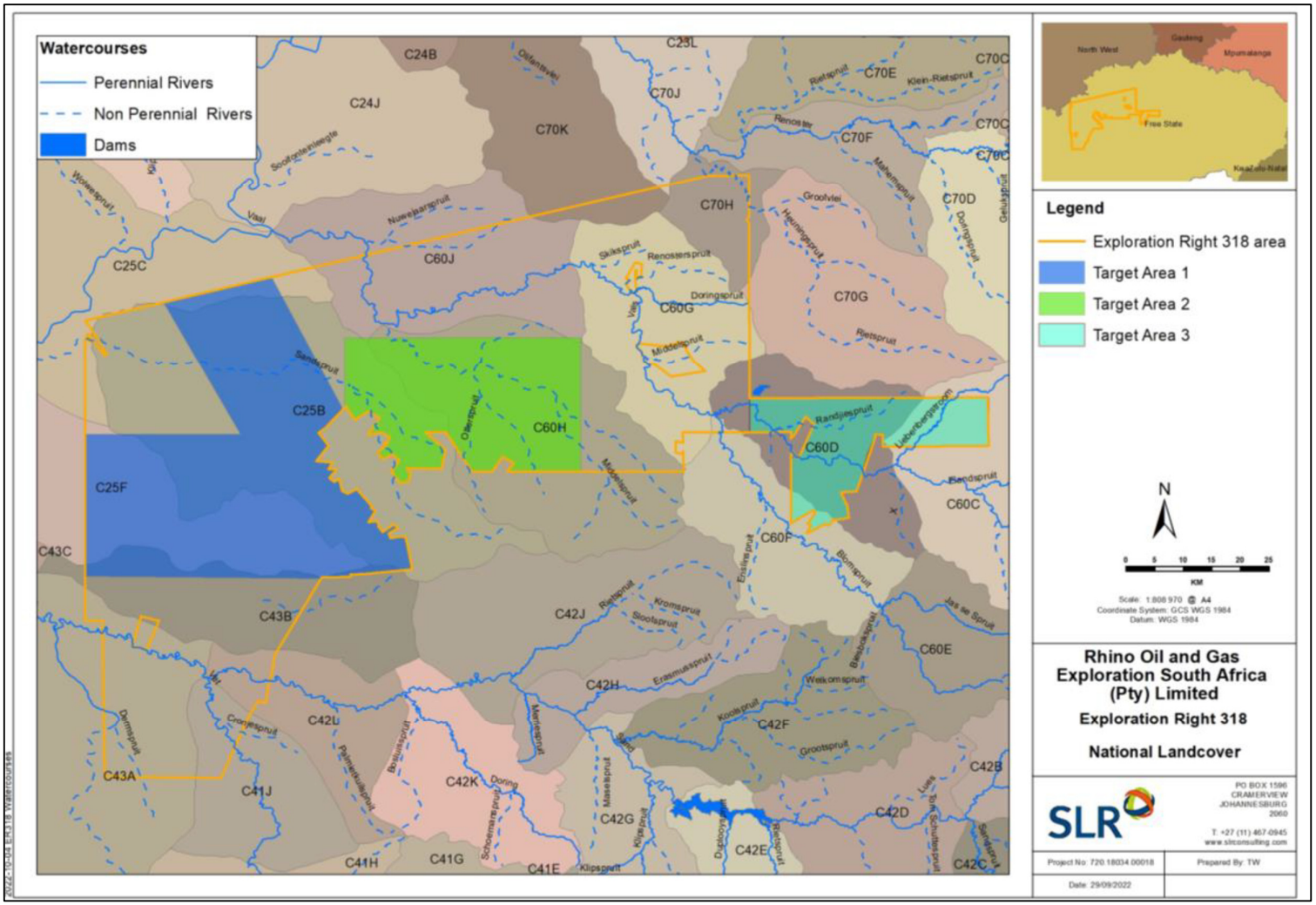

Figure 5-5: Water resources

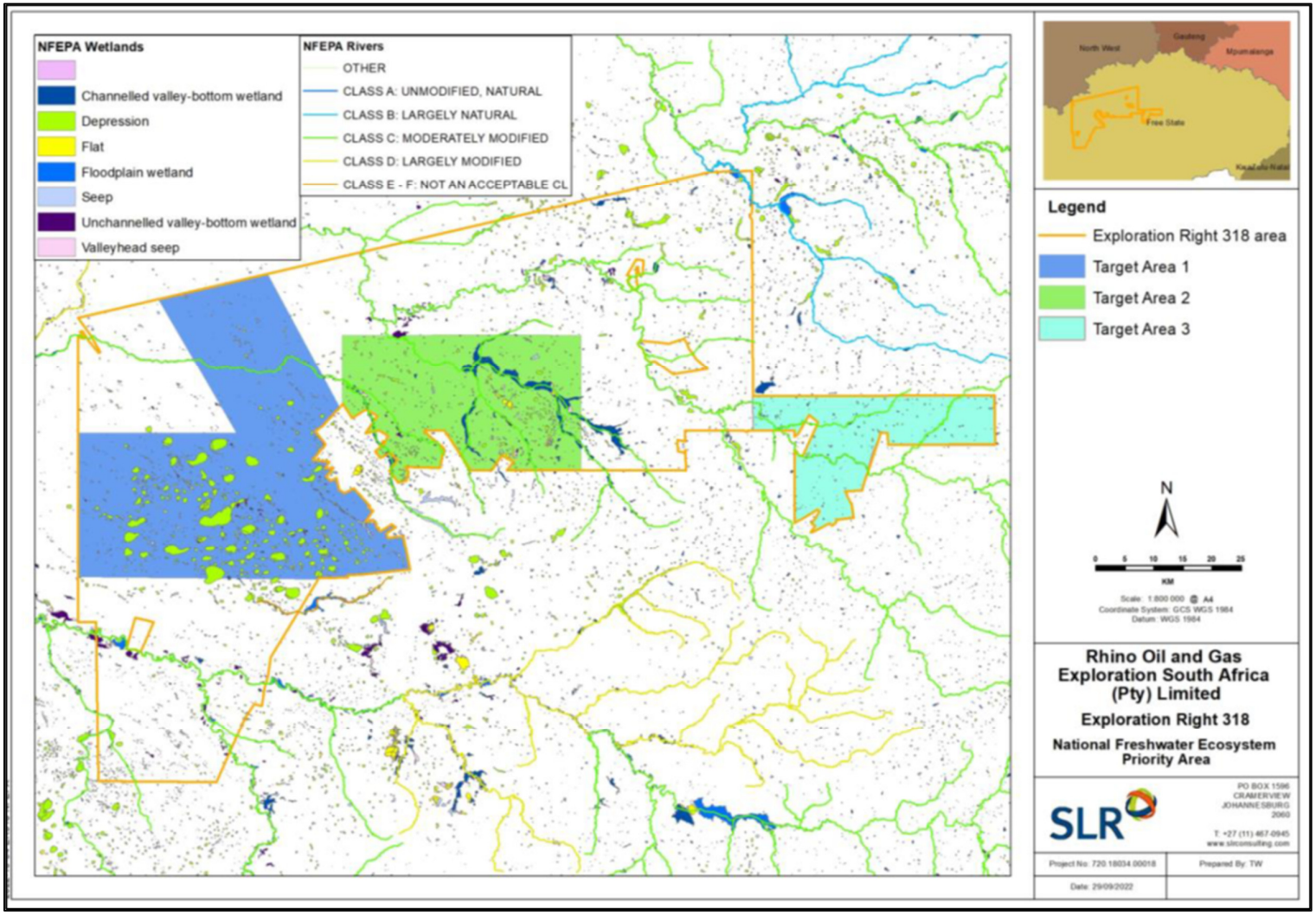

Figure 5-6: NFEPA wetlands within the target areas

5.11 Biodiversity

Biodiversity refers to flora (plants) and fauna (animals). According to the International Union for Conservation of Nature (IUCN) (2011), biodiversity is crucial for the functioning of ecosystems which provide us with products and services which sustain human life. Healthy ecosystems provide us with oxygen, food, fresh water, fertile soil, medicines, shelter, protection from storms and floods, stable climate and recreation.

A brief description of fauna and flora located within the Well Drilling Target Areas is provided below.

5.11.1 Flora

The proposed Well Drilling Target Areas are located within the Grassland Biome and the Savannah Biome. The Grassland Biome comprises the Dry Highveld Grassland Biogregion and Sub-escarpment Savanna including an Inland Azonal Vegetation area. For detail pertaining to the various vegetation unites located within the proposed Target Areas refer to Table 5-4. The distribution of the various vegetation units within the Target Areas is illustrated in Figure 5-7.

Table 5-4: Biomes and vegetation units

Biome	Bioregion/Azonal areas	Vegetation unit	Conservation status
Grassland	Dry Highveld Grassland	Vaal-Vet Sandy Grassland	Endangered
		Eastern Free State Clay Grassland	Least concern
		Western Free State Clay Grassland	Least concern
		Vredefort Dome Granite Grassland	Vulnerable
		Central Free State Grassland	Least concern
	Sub-escarpment Grassland bioregion		Vulnerable
Savannah	Sub-escarpment savannah	Eastern Kalahari Bushveld Bioregion	Least concern
Azonal vegetation	Alluvial vegetation	Highveld Alluvial Vegetation	Least concern

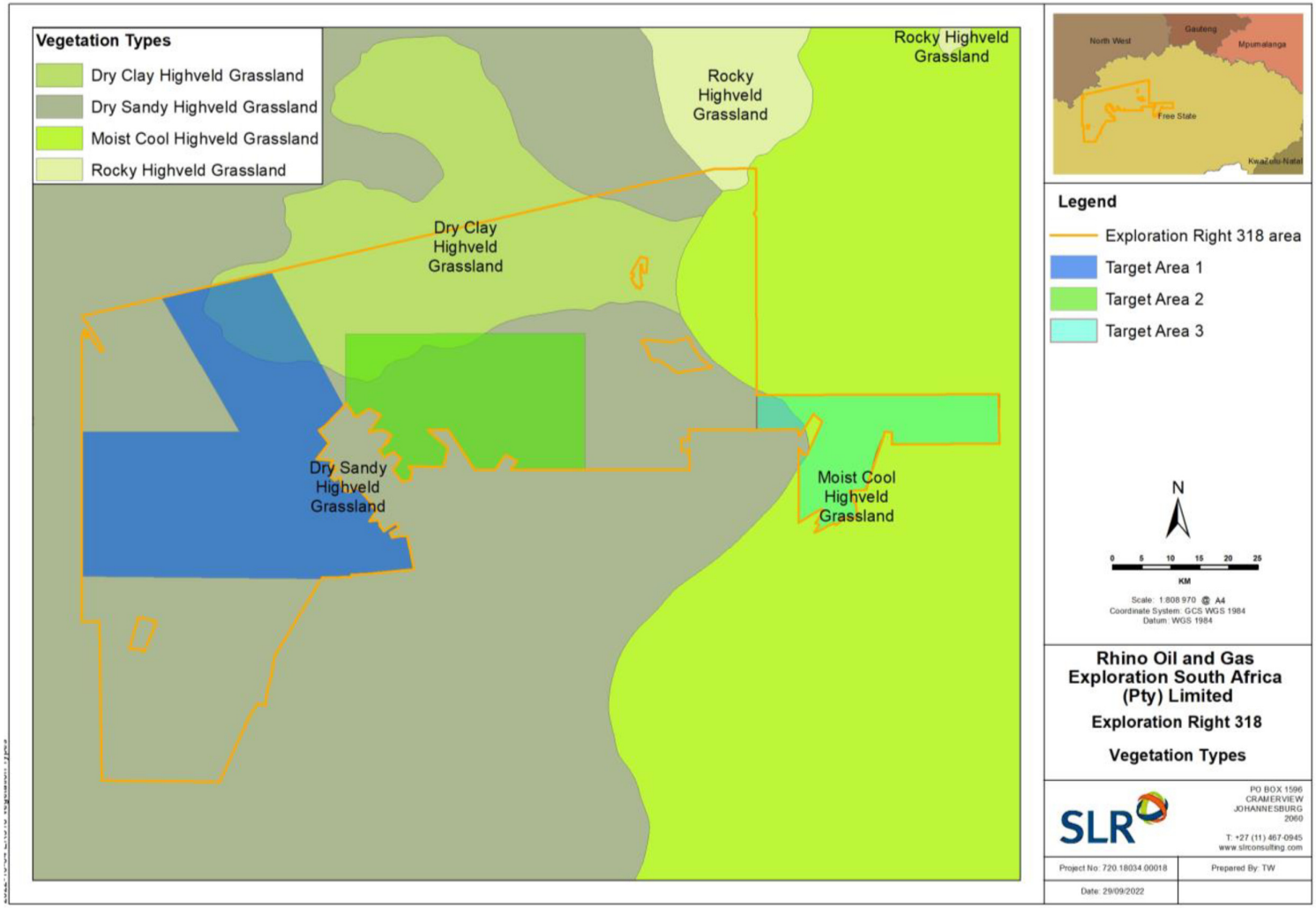

Figure 5-7: Vegetation types (Mucina and Rutherford, 2006)

5.11.2 Fauna

Numerous faunal species such as birds, amphibians, reptiles, mammals, fish and insects are associated with the various vegetation units located in the Well Drilling Target Area.

Eighty-nine (89) (37.7 % of expected) avifaunal species were recorded in the application area during the survey based on either direct observation, vocalisations, or the presence of visual tracks & signs. Four (4) species are rated as Species of Conservation Concern (SCC), whereas 75 were listed as protected provincially.

Twenty-two (22) mammal species were observed during the survey of the Well Drilling Target Areas based on either direct observation or the presence of visual tracks and signs. Three (3) of the species recorded are regarded as SCC.

Four (4) mammal species are considered 'captive' species as these were only present within the game farm areas.

Eleven (11) species of reptiles were recorded in the application area during survey period. One SCC, namely *Smaug giganteus* (Sungazer/Giant Dragon Lizard) was recorded during the field assessment. However, there is the possibility of more species being present, as certain reptile species are secretive and require long-term surveys to ensure capture.

Four (4) amphibian species were recorded in the application area with only one of these species recorded is a SCC.

Significant parts of the study area are cultivated or have been previously cultivated and are therefore not considered to have high sensitivity or biodiversity value. There is also an area that is currently being mined and contains mining infrastructure. Natural habitats are considered for various reasons to have high biodiversity value and are avoided during planning phases for the proposed activities, where possible.

5.12 Conservation sites

The conservation status of the area as well as the protected areas associated with the exploration activities is provided in this section.

5.12.1 Protected areas

While several formally protected areas area located within close proximity to the Target Areas, all areas with protected status under the National Environmental Management: Protected Areas Act, 2003 (No. 57 of 2003); Biodiversity Act, 2004 (Act 10 of 2004); National Forests Act, 1998 (No. 84 of 1998) and Mountain Catchment Areas Act, 1970 (No. 63 of 1970) have been excluded from the extent of the ER area (see Figure 5-8). Thus, no exploration activities will occur within these Protected Areas.

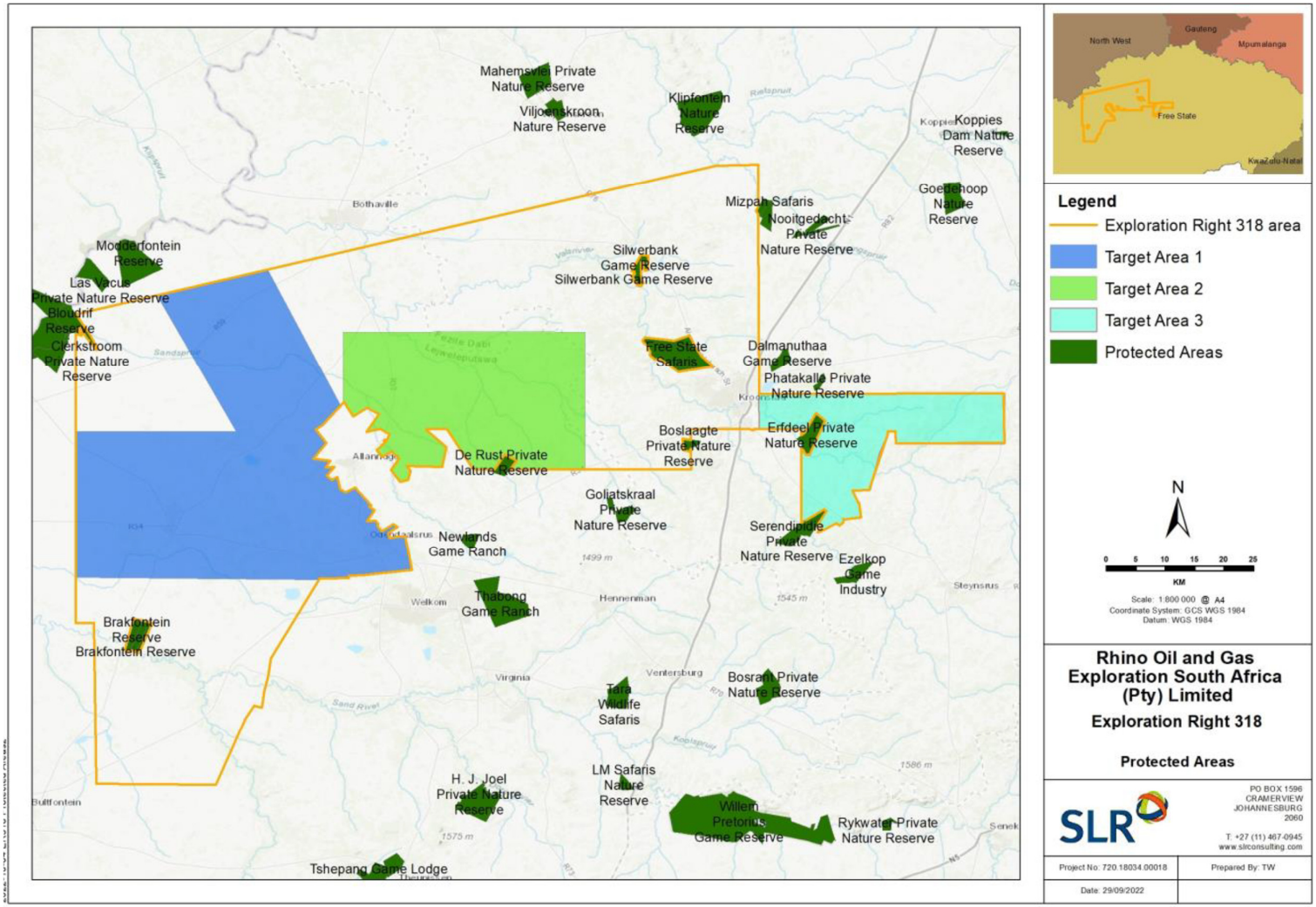

Figure 5-8: Location of formally protected areas outside of the proposed Target Areas

5.12.2 National Protected Area Expansion Strategy

The aim of the National Protected Area Expansion Strategy (NPAES) is to achieve cost effective protected area expansion for ecological sustainability and adaptation to climate change. The NPAES sets targets for protected area expansion, provides maps of the most important areas for protected area expansion, and makes recommendations on mechanisms for protected area expansion. It deals with land-based and marine protected areas across all of South Africa's territory (SANBI BGIS).

With reference to Figure 5-9, the ER area overlaps with the Free State Highveld Grasslands NPAES focus area. Focus areas are important for the land-based protected area expansion network as these areas are large, intact and unfragmented areas which are suitable for creation or expansion of large, protected areas. However, it is noted that NPAES boundaries should never be literally interpreted as future protected area Boundaries (DEA, 2016).

5.12.3 National Threatened Ecosystems

Section 52 of the National Environmental Management: Biodiversity Act, 2004 (No. 10 of 2004) provides for the listing of threatened ecosystems at both national and provincial level. No critically endangered ecosystems are located within the proposed Target Areas (Mucina and Rutherford, 2006). The Vaal-Vet Sand Grassland is listed as endangered ecosystem and is found within the Target Areas (see Figure 5-7).

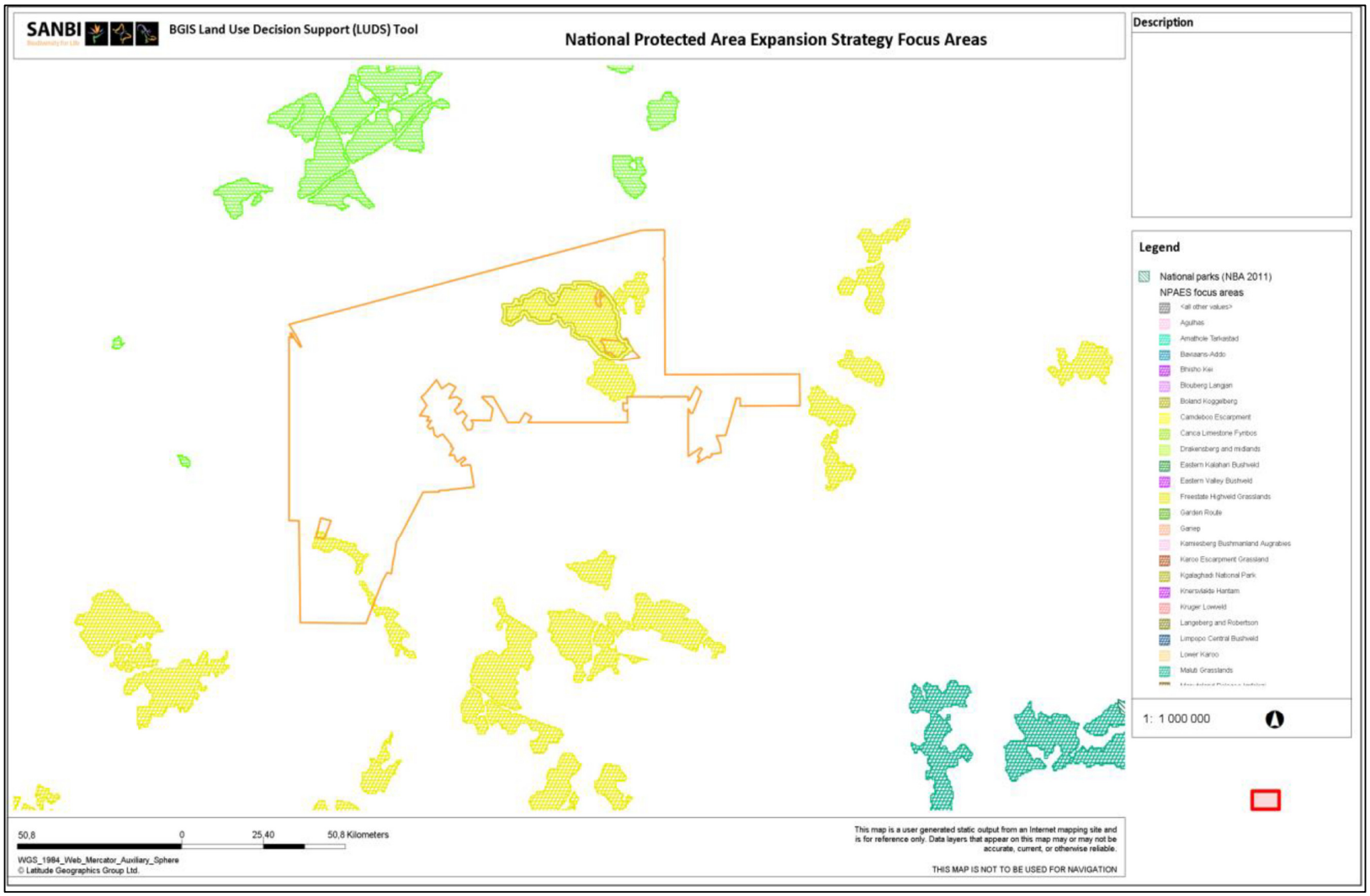

Figure 5-9: Exploration Right area in relation to the proposed NPAES areas

5.12.4 Freshwater Ecosystems

The Water Research Commission and partners undertook the National Freshwater Ecosystem Priority Areas project (NFEPA). The NFEPA project produced several outcomes including the Atlas of Freshwater Ecosystem Priority Areas in South Africa, which provides strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. The NFEPA is supported by an implementation manual that provides guidance on the use of FEPA maps when planning and decision-making impacts on freshwater ecosystems. The manual provides ecosystem management guidelines for river FEPAs, wetland FEPAs, sub-quaternary catchments associated with river FEPAs, and Upstream Management Areas. The purpose of freshwater ecosystem management is to conserve biodiversity patterns and ecological processes and to maintain natural variability. Management should aim to prevent the occurrence of large-scale damaging events, as well as the repeated, chronic, persistent, subtle events.

There are numerous NFEPA Rivers and wetlands located within the proposed exploration area (refer to Figure 6-5 above). The present ecological state of the NFEPA Rivers located within the proposed exploration area are either classified as Class C (Moderately modified), Class D (Largely modified) and Class E (Seriously modified). It follows that all the NFEPA Rivers located within the proposed exploration area have been modified to some extent. No natural or unmodified NFEPA rivers are located within the proposed exploration area. The wetlands located within the proposed exploration area include a combination of Channelled valley-bottom wetlands, depressions, flat, floodplain wetlands, seeps, unchanelled valley-bottom wetlands and valley head seep.

According to the NFEPA implementation manual, mining in any form (including prospecting/exploration) should not be permitted in wetland FEPAs or within 1 km of a wetland FEPA buffer, or within 1 km of a riverine buffer (including all associated wetland systems and tributaries) within a FEPA catchment. It is noted that there is no legislation regarding buffers around rivers or wetlands in the NWA. The width of a buffer required around a river or wetland depends on many factors such as the risk the proposed development poses to the water resources, the sensitivity of receiving environment and the proposed mitigation measures.

5.12.5 Critical Biodiversity Areas

The Free State Biodiversity Sector Plan, 2016 was developed with cognisance of the requirements for the determination of bioregions and the preparation and publication of bioregional plans (DEAT, 2009). To this end, the two main products of this biodiversity sector planning process includes:

- A map indicating the different terrestrial categories (Protected, Critical Biodiversity Areas (CBAs), Ecological Support Areas (ESAs), Other and Degraded); and
- Land-use guidelines for the above-mentioned categories.

The Free State Biodiversity Sector Plan represents the first attempt at collating all terrestrial biodiversity and ecological data for the province into a single system from which it can be interrogated and assessed. Biodiversity and ecological data included are:

- Land cover data;
- Inselbergs;
- Species distribution data (from records and expert mapping);
- Modelled species distribution;
- A range of national data sets (Vegetation types, NFEPA sub-catchments);
- The existing Ekangala spatial biodiversity plan;
- Biodiversity plans of neighbouring provinces; and
- Existing provincial plans that guide development within the Free State Province, most notably the Provincial Spatial Development Framework (PSDF).

Interrogation and assessment of the data was done according to national accepted biodiversity planning principles, i.e. classification of the landscape was done according to a systematic and a quantitative approach. Included in the assessment was the incorporation of edge matching principles to ensure that planning units across provincial boundaries have similar classifications (CBA, ESA, etc.) where appropriate.

Large portions of the Free State have been degraded and are not available for conservation. According to the 2009 land cover map of the Free State, portions of the province are degraded (18%) while 33.67% is transformed (urban development, agriculture). Only 1% of the Free State is covered by Formal Protected areas (Provincial Nature Reserves and SANParks).

The Target Areas proposed by Rhino include several areas classified as Critical Biodiversity Areas and Ecological Support Areas, however the majority of the Target Areas are mapped as Degraded or Other (see Figure 5-10).

5.12.6 Important Bird Areas

Important Bird Areas (IBAs) were initiated by BirdLife International to conserve a network of specific sites that are critical in the long-term survival avifaunal species. The following criteria was used in selecting the IBA's:

- Globally threatened species;
- Restricted range;
- Restricted to specific vegetation types or biomes; and
- Significant population numbers for a specific area.

No IBAs are located within the ER or proposed Target Areas (Figure 5-11).

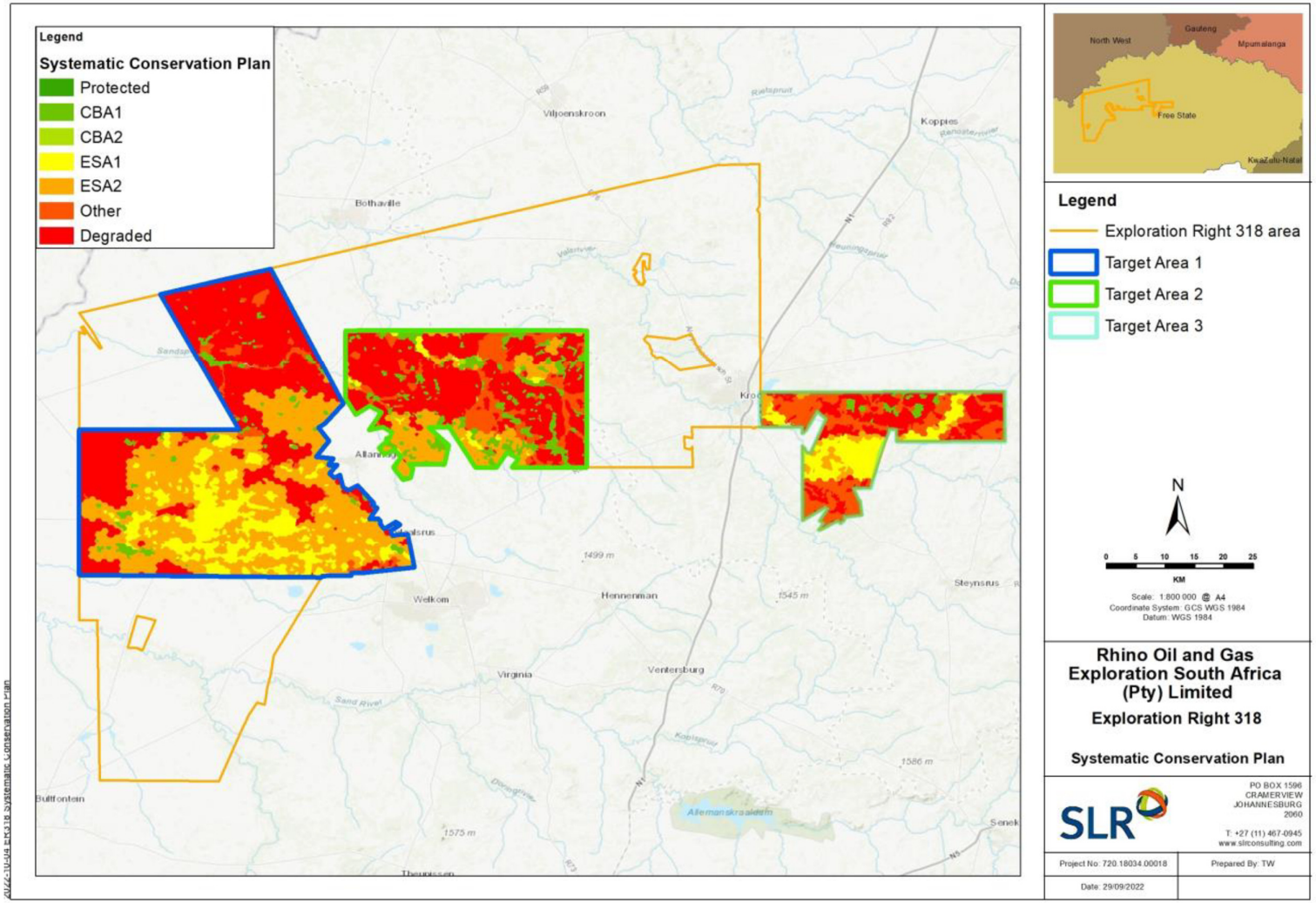

Figure 5-10: Mapped terrestrial categories of the Free State Biodiversity Sector Plan within the proposed Target Areas

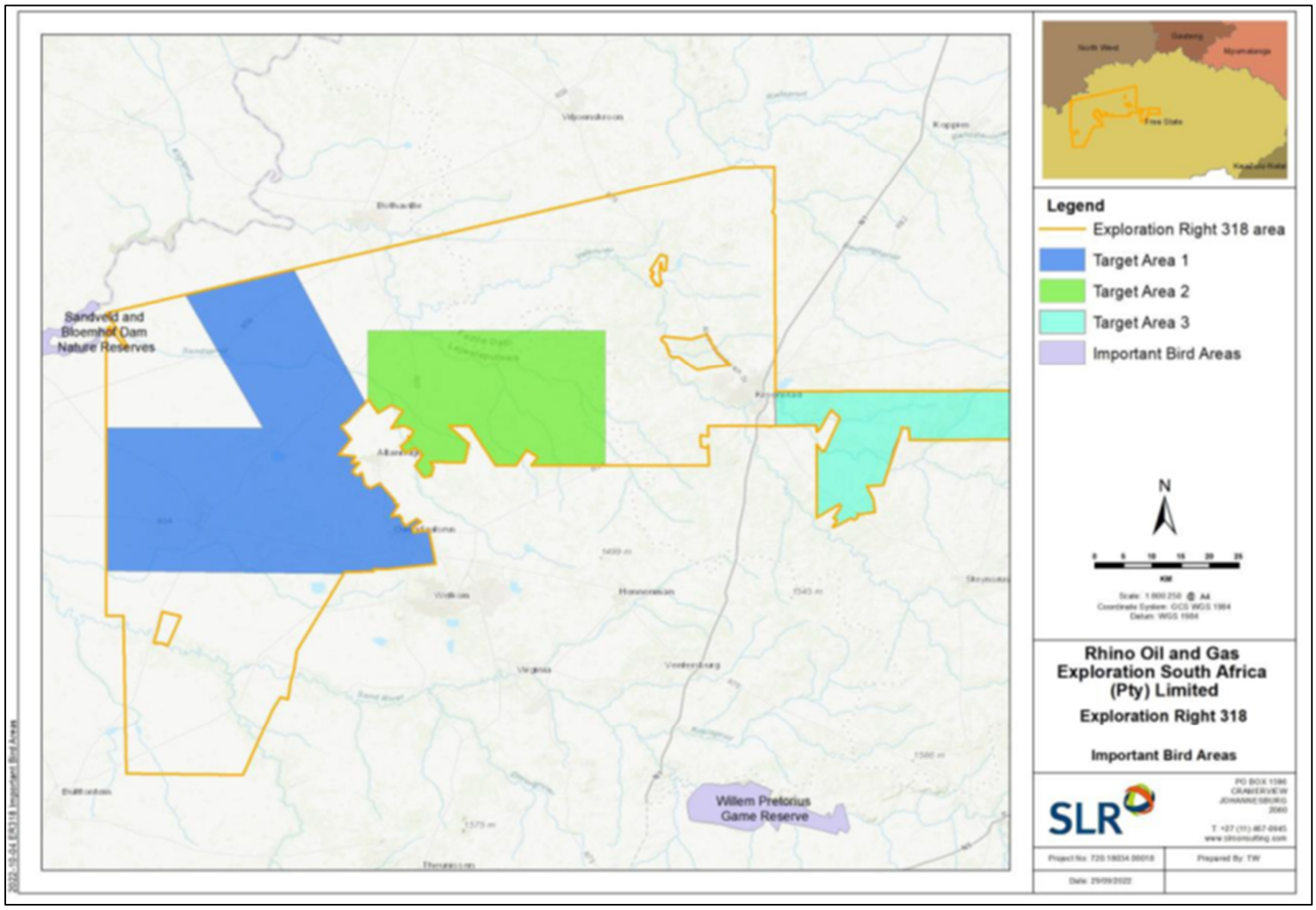

Figure 5-11: Location of the Target Areas in relation to Important Bird Areas

6 ENVIRONMENTAL RISK ASSESSMENT

The Financial Provisioning Regulations requires that an environmental risk assessment must be undertaken for all areas of infrastructure or activity or aspects for which a holder of a right or permit has a responsibility to mitigate an impact or risk at closure. The findings of this risk assessment aim to guide the appropriate closure strategies.

This final rehabilitation, decommissioning and closure plan has been updated to include reflect the current understanding of the project and the associated risks related to rehabilitation, decommissioning and closure. The risk assessment aims to reflect the risks associated with the closure of the wells.

6.1 Risk assessment methodology

Environmental risks have been identified through review of the proposed exploration activities and the existing environment. The identification of risks was undertaken as follows:

- Professionals, including an Environmental Assessment Practitioner, wetland specialist, soils and land capability specialist, a hydrogeological specialist, and a team of as part of the relevant Environmental Impact Assessment process; and
- If and where, risks or impacts are identified through the ongoing monitoring and stakeholder engagement process these are included and assessed.

The impact significance, or risk rating methodology as presented herein is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The broad approach to the significance rating methodology is to determine the environmental risk by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. The environmental risk is determined for the pre- and post-mitigation scenario.

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:

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

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 6-1 below.

Table 6-1: Criteria for determining impact consequence

Aspect	Score	Definition
Nature	-1	Likely to result in a negative / determinantal impact
	+1	Likely to result in a positive / beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)

Aspect	Score	Definition
	2	Site (i.e. within the development property boundary)
	3	Local (i.e. the area within a 5km radius of the site)
	4	Regional (i.e. extends between a 5km and 50km radius from the site)
	5	Provincial / National (i.e. extends beyond 50km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years)
	3	Medium term (6-15 years)
	4	Long term (16-65 years, the impact will cease after the operational life span of the project)
	5	Permanent (>65 years, 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, moderate improvement for the impacts)
	4	High (where natural, cultural, or social functions or processes are altered to the extent that it will temporarily cease, high improvement for the impact)
	5	Very high / don't know (where natural, cultural or social functions or processes are altered t the extent that it will permanently cease, substantial improvement for the impacts)
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 impacts

Once the Consequence has been determined, the environmental risk is determined in accordance with the standard risk assessment relationship by multiplying the Consequence and the Probability. Probability is rated/ scored as per Table 6-2.

Table 6-2: Probability rating

	Score	Description
Probability	1	Improbable (the possibility of the impact materializing is very low as a result of design, historic experience, or implementation of adequate corrective actions; less than 25%)
	2	Low probability (there is a possibility that the impact will occur; between 25% and 50%
	3	Medium probability (the impact may occur; between 50% and 75%
	4	High probability (it is most likely that the impact will occur; more than 75%
	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:

$$\textit{Environmental Risk} = C \times P$$

The outcome of the environmental risk assessment will result in a range of possible scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 6-4.

Table 6-3: Environmental risk scores

Score	Description
>9	Low (i.e. where this impact is unlikely to be a significant environmental risk / reward
≥9 ≥17	Medium (i.e. where the impact could have a significant environmental risk / reward
>17	High (i.e. where the impact will have a significant environmental risk / reward)

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.

6.2 Risk and impact identification

The identification of management and mitigation measures are guided by the hierarchy of mitigation. The ultimate aim being to avoid or mitigate detrimental impacts on the environment, and to optimise positive environmental impacts, and for matters pertaining thereto. Table 6-5 lists the environmental impacts and risks identified which relate to final rehabilitation, decommissioning, and closure.

The relevant management and mitigation measures are listed. The applicable conceptual closure strategy to avoid, manage and mitigate the impacts and risks are also included in Table 6-5, together with the reassessment of the environmental risk after mitigation. The environmental risk assessment of the impacts associated with final rehabilitation, decommissioning and closure has informed the most appropriate closure strategy for the project. Impacts that are classified as high-risk post-mitigation are likely to represent either latent or residual environmental impacts and financial provision will be provided to remediate these specific impacts. Please see Section 6 for further details.

The environmental risk scores are defined as **Low (<9)**; **Medium (≥9; ≤17)**; and **High (> 17)**. Positive impacts have not been colour-coded. It is important to note that the environmental risk assessment will be revised and updated on an annual basis to ensure that this final rehabilitation, decommissioning and closure plan remains applicable to the actual and predicted environmental impacts and risks. The EMPr addresses the management and mitigation of environmental impacts associated with the planning and exploration phases whilst the three reports and plans as prescribed in the Financial Provisioning Regulations, 2015 (to be reviewed annually) will provide for the planning and financial provisioning for the concurrent rehabilitation and final closure of the exploration activities.

6.3 Environmental risk assessment for rehabilitation, decommissioning and closure

This risk assessment identifies and assesses the environmental risks and potential impacts associated with the future rehabilitation, decommissioning and closure of the proposed exploration activities. Where practical the mitigation hierarchy is applied to limit the post mitigation risk or impact significance. However certain impacts will perpetuate beyond the closure period and are identified described and assessed as residual and/or latent impacts in Section 11.1.

Table 6-5 provides a summary of the identified impacts, associated level of risk (or significance rating) both pre- and post- mitigation, the identified key management and mitigation actions, and finally the identified broad closure strategy.

Table 6-4: Impact Assessment for Rehabilitation, Decommissioning and Closure

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
Social	Potential to use local service providers and contribute directly to local economy.	+11.00	Use of local service providers for appropriate services.	+11.00	N/A
	Interference with existing land uses.	-15.00	Particulate matter (PM) emissions reduction along the unpaved roads, decommissioning areas, and within the proposed site boundary could include either watering or chemical suppressants, which can achieve up to 75% and 90% control efficiency respectively.	-11.00	On-going monitoring. Implement effective dust control measures. Revegetation of disturbed areas
	Impacts on existing services and infrastructure.	-14.00	If private roads are affected by project activities, it is the responsibility of Rhino to maintain these roads as long as they use it. Rhino should engage with the relevant farmers about road maintenance, as some of them have preferential ways in which the roads must be maintained, for example if roads are only graded and not built up it turns into rivers when there is heavy rain. The road maintenance agreements must be formalised before well drilling commences to ensure all parties involved are protected and know their rights and responsibilities. It is recommended that well drilling be planned for the dry season. Rhino must provide all the affected landowners with a well drilling schedule to ensure that they know when activities will take place on their properties. Any changes to the schedule must be communicated to the farmers at least a week in advance.	-13.00	Ongoing landowner and stakeholder engagement.

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			Before the project commences Rhino should compile an asset and infrastructure baseline of any landowner infrastructure that may be affected by the project. Photographs and GPS coordinates of the infrastructure must be included in the baseline. A copy of the baseline affecting their property should be given to each landowner, who should sign off the document to ensure that it is accurate. Rhino should keep the master document. If any damage occurs, it should be reinstated to its pre-project status. If the infrastructure must move, it must be done at Rhino's cost. Rhino must ensure that the drilling team has a copy of the asset and infrastructure baseline to guarantee that no infrastructure will be damaged due to ignorance during the construction phase of the project. Notice of any service interruptions must be given at least 24 hours before the interruption takes place – a SMS or e-mail system can be used for this purpose.		
	Re-instatement of access routes give access to land/infrastructure that was cut off by the project.	-13.00	It may be unavoidable to change travel patterns. It is important to inform the affected stakeholders about the possibility of this impact as soon as possible. It will allow them time to get used to the idea and plan their activities accordingly. It is also important that locally affected parties give input in potential mitigation measures.	-9.00	Ongoing landowner and stakeholder engagement.

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			Before well drilling commences Rhino must meet individually with each applicable landowner to discuss their movement patterns and needs. Rhino must provide all the affected landowners with a drilling schedule to ensure that they know when exploration will take place on their properties. It is recommended that well drilling be done outside the peak planting and harvesting seasons. Any changes to the schedule must be communicated to the farmers at least a week in advance. As far as possible obstruction of access routes and sensitive areas must be avoided. If it cannot be avoided both parties must agree on alternative routes, and Rhino should carry the cost of implementing the alternatives. Industrial vehicles should not travel during peak traffic times. If practical and required by the landowner, access routes to land/infrastructure should be reinstated in the decommissioning phase. This must be done in conjunction with the landowners.		
	Increase in social license to operate due to management of nuisance impacts.	-12.00	This is a positive impact (post mitigation) and will occur if Rhino implements the suggested mitigation measures.	+11.00	Landowner consultation

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			Rhino should appoint a dedicated person to communicate with the landowners. It is important for the landowners to build a relationship with this person. The person must have enough authority and access to management to ensure that he can assist with dealing with everyday issues. It is important that the landowners trust the person and have faith in their ability to address issues. In addition, Rhino should establish a Community Liaison Forum that meets at least twice a year. The forum can be used to share information and give feedback on general and environmental issues. Before the project commences the exploration programme must be shared with the affected parties.		
	Impacts on safety and security of local residents due to presence of unfamiliar people in the area.	-13.00	Rhino should work with the existing farmers' security groups and farmers' associations to create a farm access protocol for everybody that need to access the properties, and a safety plan. Rhino should also become a member of the local community forums and security groups and farmers' associations. Farms that are equipped with alarms are all connected to a central security point, and this is a good point of departure for Rhino to consider security arrangements for their own assets and to link in and work with existing systems.	-11.00	Ongoing landowner and stakeholder engagement.

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			Pictures, make and registration numbers of all vehicles used by Rhino on site should be provided to the farmer's security group and distributed to all affected landowners to ensure that they will be able to identify these vehicles if they access their properties. In addition, for scheduled and maintenance work Rhino should give a roster to the farmers stating dates and approximate times that contractors will be on the farms. All access arrangements should be made at least 24 hours before access is required. Rhino must meet with the landowners before the construction phase commence and formalise security arrangements. This should be done in writing and include the existing forums that the landowners know and trust. Vehicles should be marked as exploration vehicles and should have Rhino's logo clearly exhibited. Entry and exit points of the site should be controlled. Areas where materials are stockpiled must be fenced. If a security company is used, their schedules should be communicated to the farmers, especially to those farmers that have Rhino infrastructure that need to be guarded. It must be considered that guards changing shifts contribute to the impact of strangers accessing properties, and therefore a system that consider the safety of both the Rhino infrastructure and the safety of the landowners must be implemented.		

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			The fact that it may be required that people spend the night on the farms is a source of discomfort for many of the landowners, especially if it is people that they do not know and trust and have no control over. Under no circumstances should anyone be allowed to erect a dwelling for security forces on any of the farms. However, the necessary sanitation facilities must be made available, and some form of shelter from the elements.		
	Alternative land-use	+8.75	All the significant enhancement measures are legislated, and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan in respect of exploration, is advised.	+8.75	
Economic	Black economic transformation	-16.00	All the significant enhancement measures are legislated, and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan in respect of exploration, is advised. The following air quality measures are recommended during construction, operational, decommissioning and rehabilitation and closure phases of the Project:	-16.00	
	Country and industry competitiveness	+18.00		+18.00	
	Economic development per capita	-13.00		-13.00	
	Employment impacts	-13.00		-13.00	
	Fiscal income	+23.00		+23.00	
	Forex savings	+23.00		+23.00	
	GGP impact	-13.00		-13.00	
	Need and desirability	-15.00		-15.00	

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
	Fugitive emissions (dust) from decommissioning/ removal of all infrastructure no longer required.	-11.00	In controlling vehicle entrained particulate matter, it is recommended that water be applied on all unpaved road sections to ensure a minimum of 50% control efficiency (CE). In addition, binding agents or chemical suppressants (such as "Dust-A-Side" or "Dustex") should be considered for application on all unpaved road sections; literature reports an emissions reduction efficiency of more than 80 % (NPI, 2011; Cecala, et al., 2012; US EPA, 2006). In order to ensure lower exhaust emissions from vehicles and machinery, equipment suppliers or contractors should be required to ensure compliance with appropriate emission standards for fleets. Also, maintenance and repair of diesel engines should be carried out as prescribed by manufacturer in order to maximize combustion and reduce gaseous emissions. Fuel efficient driving practices on site may also help lower exhaust emissions from vehicles and machinery, such as stipulating a maximum speed on all unpaved roads and limiting unnecessary travelling of vehicles on untreated roads. In addition, other fuel efficient practices that may lower exhaust emissions include limiting idling of machinery, driving in an upper gear rather than a lower gear as much as possible, ensuring tire pressure are always adequate etc.	-7.50	Compliance with EMPr. On-going monitoring. Implement effective dust control measures. Revegetation of disturbed areas

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			The use of low–NOx burners in combustion systems should be considered during operations. Products, liquid fuels and chemicals should be stored in areas where there are provisions for containment of spills. The implementation of vapour recovery systems, for storage tanks and other applicable units, to control losses of VOCs and achieve over 90% recovery, should be considered. During construction and rehabilitation phases, stockpile of fine or erodible material (if applicable) should be treated regularly with water sprayers to reduce their potential for erosion. Infrastructure containing natural gas and associated GHG's and/or pollutants (including amongst others pipelines, processing plant, and storage vessels) must be cleared and captured, and not vented directly to the atmosphere.		
Air quality	Contamination of alluvial and sand aquifers	-6.50	In most instances, the hydrogeological impacts associated with surface sources are linked to spills and leaks, which can be managed through the implementation of good housekeeping practices, regular inspections as well as sound environmental training. The regional extent of these impacts is not expected to be significant but would rather be restricted to the site.	-2.30	Compliance with EMPr. Rehabilitate disturbed areas. On-going monitoring.

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			An emergency response protocol must be implemented at the operations that are aimed at early detection and swift reaction speed. In this regard, daily inspections of drilling pads must be implemented. Specific emphasis must be placed on detecting leaks and spills during the inspections. An on-site communication system must be put in place to ensure that instructions are given and carried out with efficiency. In the event of a spill occurring, a method statement must be completed that describes how, where and when clean-ups will be undertaken. The on-site communication system must make provision for continual review and improvement of spill management. The necessary equipment and personal protection equipment (PPE) must be kept on site to clean spills up and leaks. Rhino personnel must receive adequate training on the use of the equipment and the disposal of waste material generated during a spill. All such wastes must be treated as hazardous. The waste must be placed of to a dedicated sealed container on site, which must be disposed of to a licensed facility.		

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			All on-site vehicle and equipment maintenance must be undertaken within an area of secondary containment, such as a bund or over a drip tray, to prevent accidental soil contamination. Oil and diesel stored on site must be placed within a suitably sized bund. The dispensing of hydrocarbons must be undertaken with due care to prevent or contain spills. All waste generated must be contained and stored in suitably sealed, bunded and protected areas to avoid spills and leaks. Waste must be collected and disposed of offsite in a responsible manner so as to prevent groundwater contamination off site.		
Hydrogeology	Stray gas migration affecting groundwater quality	-16.00	The shallow potable Karoo aquifers will be protected during gas exploration drilling through the insertion of several well casings and cementation. Well design will be undertaken according to designs developed by a qualified well engineer. Well design will be undertaken according to designs developed by a qualified well engineer. The upper 450m to 600m of the geological succession will be cased off using a combination of telescopic drilling, steel casing and cementation between the well annulus and the casing. This configuration is aimed at isolating the shallow Karoo potable aquifer from the deep-seated gas production zone and the saline formation water associated with the production zone.	-9.00	Plug entire length of well and cap well. Compliance with EMPr. Ongoing Monitoring.

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Post-mitigation risk	Closure options / actions
			In the unlikely event that produced water has to be extracted from gas exploration wells during testing, this water will be stored in sealed containers, removed from site and disposed of to a suitable licenced (where necessary) environment/waste management facility. The produced water is expected to contain elevated levels of dissolved salts, hydrocarbons and trace elements and would therefore be harmful to the environment. Responsible disposal thereof is therefore important. A groundwater monitoring programme will be implemented in the gas well as well as in the monitoring and hydrocensus boreholes to detect dissolved methane and ethane gas.		

7 DESIGN PRINCIPLES

There are no legislatively defined principles guiding the design or the rehabilitation, decommissioning and closure plans for onshore gas exploration in the South African context.

7.1 General surface rehabilitation

The Land Rehabilitation Society of South Africa (LARRSA) has recently published a guideline for the surface rehabilitation of coal mines (LaRSSA, 2019). There are however aspects of these guidelines which can be applied to the surface rehabilitation actions for most projects (including gas exploration projects) and are presented in Table 7-1.

7.2 Borehole plugging and abandonment

In respect of the rehabilitation plugging and abandonment reference has been made to the American Petroleum Institute (API) recommended Practice 65-3 (American Petroleum Institute, 2021). This document provides practical guidance for permanently and temporarily abandoning gas wells.

The primary goals of the practice document are protection of useable water sources, isolation of hydrocarbon bearing or water injection intervals, prevent any leakage to the surface, and prevention of unintended cross flows. Where applicable and relevant recommendations and actions defined in this practice document has been included in this final, rehabilitation and closure plan.

Table 7-1: Key principles for surface land rehabilitation

Component	Rehabilitation principle
Regulatory compliance	• Achieving legal compliance is a minimum requirement for appropriate rehabilitation planning. • Rehabilitation objectives and associated actions will not conflict with local legislation and will aim to complement and possibly go beyond legal compliance, where possible.
Concurrent implementation	• Concurrent, progressing rehabilitation will be undertaken throughout the operational stage of the exploration. • A risk-based approach will be applied to ensure concurrently implemented rehabilitation actions will achieve the desired post-mining landscape and land capability with end land use targets.
Stakeholder engagement and custodianship	• Relevant exploration-affected stakeholders will be identified and involved in rehabilitation planning throughout the activity lifecycle, as required. • Rehabilitation planning will leverage from local stakeholder views, experiences, cultures and/or customs on possible uses and needs of the rehabilitated landscape, to foster a land stewardship culture from potential next land users.
Landform management	• Rehabilitation will be undertaken and aligned to a site-specific surface landform design that will be compiled during the planning stage of an operation. • The site-specific landform design will incorporate the surface profiling needs of the target post-exploration land capability and land use(s), to optimize material movement throughout the operational and decommissioning periods, and to ensure the long-term sustainability of the rehabilitated landscape.
Land capability	• Post-activity land capability will, as far as it is practically possible, be constructed to resemble the pre-activity land capability of the disturbed area. • Attention will be given to rehabilitating the site to specified land capabilities that can support a suite of mixed land uses. • Soil physical and chemical properties will be aligned to the productivity needs of the post-activity land use(s), and to support these in the long term.
Land use	• Post-activity land use planning will consider the needs of changing regional development and planning, over time. • The site will be left in an environmentally, physically safe, stable, and non-polluting condition for the defined post-activity land uses. • The defined post-activity land use(s) will provide socio-economic value to next land users, as agreed with these land users (once exact post-activity land used can be defined).
Climate uncertainty	• Predictive modelling will form the basis for longer-term environmental impact identification and risk management, where applicable.
Monitoring	• Monitoring will be initiated as soon as the first ground have been moved (at construction).

Component	Rehabilitation principle
	• Monitoring will be continued progressively throughout the project lifecycle, in parallel with concurrent rehabilitation activities. • Data obtained through ongoing monitoring will be frequently assessed for trends that could demonstrate rehabilitation success, and where corrective action may be required. • The monitoring process must be linked to a corrective action process.
Adaptive land management	• An adaptive land management approach will be adopted on-site, allowing for implementation of alternative and improved rehabilitation strategies and corrective actions, where required.

7.3 Gas well closure sealing and rehabilitation guidelines

The guidelines provided in this section has the aim to provide guidance during the preparation of well closure, sealing and abandonment of gas exploration wells, with a focus on the following aspects:

1. Determination of the most suitable and appropriate closure, sealing and rehabilitation strategy with specific focus on the following:
    - Technical aspects pertaining to plugging mechanisms/techniques in order to ensure the most suitable and appropriate well specific closure, sealing and rehabilitation strategy is implemented. Specific focus will be placed on plugging methods to ensure no vertical gas and/or fluid movement within the wells will take place.
    - Specifications of plugging material and equipment to ensure compliance with well abandonment standards (e.g. Best Practice Standards, etc.).
    - Ensuring the landscape safe, stable and non-polluting over the long-term, and that the post-closure land use aligns with the surrounding land use and does not affect the sustained utilization thereof.
    - Mechanisms and tests that would be implemented to ensure cement bonding is structurally sound.
    - Mechanisms and tests that could be implemented for future long-term monitoring to ensure well plugging and sealing is structurally sound.
2. Preparation of a consolidated site-specific closure, sealing and rehabilitation plan and project cost-breakdown.

These guidelines have been considered and where relevant incorporated into the final rehabilitation, decommissioning and closure plan.

7.4 Legislative and governance framework

The requirement for final rehabilitation, decommissioning, and closure stems primarily from the legislative requirements of the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002) and the National Environmental Management Act (Act No. 107 of 1998). The relevant extracts from each of these is presented in the section below.

7.4.1 Mineral and Petroleum Resources Development Act (Act No. 28 of 2002)

The following extracts relate to the principle of closure for any right issued under the Act:

- Section 69 (2) (a) retrospectively extends the relevance of several mineral provision in the MPRDA to petroleum exploration and production including, amongst others, Section 43. Section 69 (2)(b) refienes specific terms in Section 43 including (i) minerals, must be construed as a reference to petroleum; (v) prospecting, must be construed as a reference to exploration; (vi) prospecting area, must be construed as a reference to exploration area; (vii) prospecting rights, must be construed as a reference to exploration rights;
- Section 43(1): The holder of a prospecting right, mining right, retention permit, mining permit, or previous holder of an old order right or previous owner of works that has ceased to exist, remains responsible for any environmental liability, pollution, ecological degradation, the pumping and treatment of extraneous water, compliance to the conditions of the environmental authorisation and the management and sustainable closure thereof, until the Minister has issued a closure certificate in of this Act to the holder or owner concerned.
- Section 43(4): An application for a closure certificate must be made to the Regional Manager in whose region the land in question is situated within 180 days of the occurrence of the lapsing, abandonment, cancellation, cessation, relinquishment or completion contemplated in subsection (3) and must be accompanied by the required information, programmes, plans and reports prescribed in terms of this Act and the National Environmental Management Act, 1998.
- Section 43 (5): No closure certificate may be issued unless the Chief Inspector and each government department charged with the administration of any law which relates to any matter affecting the environment have confirmed in writing that the provisions pertaining to health and safety, and management pollution to water resources, the pumping and treatment of extraneous water and compliance to the conditions of the environmental authorisation have been addressed.
- Section 43 (7): The holder of a prospecting right, mining right, retention permit, mining permit, or previous holder of an old order right or previous owner of works that has ceased to exist, or the person contemplated in subsection (2), as the case may be, must plan for, manage and implement such procedures and such requirements on mine closure as may be prescribed.
- Section 43 (8): Procedures and requirements on mine closure as it relates to the compliance of the conditions of an environmental authorisation, are prescribed in terms of the National Environmental Management Act, 1998.

7.4.2 Mineral and Petroleum Resources Development Act (Act No. 28 of 2002) Regulations

The following extracts from the Regulations provided in Table 7-2, associated with the Act are specifically applicable to the compilation of the final rehabilitation, decommissioning and closure plan:

Table 7-2: Regulations associated with the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002) associated with the final rehabilitation, decommissioning and closure plan

Regulation	Requirements
Regulation 56 (read with Regulation 69): Principles for mine closure: In accordance with applicable legislative requirements for operational closure, the holder of a prospecting right, mining right, retention permit or mining permit must ensure that -	➢ the closure of a prospecting or mining operation incorporates a process which must start at the commencement of the operation and continue throughout the life of the operation; ➢ the closure of a prospecting or mining operation incorporates a process which must start at the commencement of the operation and continue throughout the life of the operation; ➢ risks pertaining to environmental impacts must be quantified and managed pro-actively, which includes the gathering of relevant information throughout the life of a prospecting or mining operation; in accordance with the provisions of the National Environmental Management Act, (Act No. 107 of 1998), the Financial Provision Regulations (2015) and the Environmental Impact Assessment Regulations (2014), as amended. ➢ the safety and health requirements in terms of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996) are complied with; ➢ residual and possible latent environmental impacts are identified and quantified; in accordance with the provisions of the National Environmental Management Act, 1998, the Financial Provision Regulations (2015) (under review) and the Environmental Impact Assessment Regulations (2014), as amended; ➢ the land is rehabilitated, as far as is practicable, to its natural state, or to a predetermined and agreed standard or land use which conforms with the concept of sustainable development; in accordance with the provisions of the National Environmental Management Act (Act No. 107 of 1998), the Financial Provision Regulations (2015) (under review) and the Environmental Impact Assessment Regulations (2014), as amended; and ➢ prospecting or mining operations are closed efficiently and cost effectively.

Regulation	Requirements
Regulation 61: Closure Objectives: Closure objectives form part of the environmental authorisation, as the case may be, and must –	➢ identify the key objectives for mine closure to guide the project design, development and management of environmental impacts in accordance with the National Environmental Management Act (Act No. 107 of 1998) and the Environmental Impact Assessment Regulations (2014), as amended; ➢ provide broad future land use objective(s) for the site; and ➢ provide proposed closure costs in accordance with the National Environmental Management Act (Act No. 107 of 1998) and the Financial Provision Regulations (2015).
Regulation 62: Contents of closure plan: A closure plan contemplated in section 43(3)(d) of the Act, forms part of the environmental management programme or environmental management plan, as the case may be, and must include –	➢ a description of the closure objectives and how these relate to the prospecting or mine operation and its environmental and social setting; ➢ a plan contemplated in regulation 2(2), showing the land or area under closure; ➢ a summary of the regulatory requirements and conditions for closure negotiated and documented in the environmental authorisation, as the case may be; ➢ a summary of the results of the environmental risk report and details of identified residual and latent impacts; in accordance with the National Environmental Management Act, 1998 and the Environmental Impact Assessment Regulations, 2014; ➢ a summary of the results of progressive rehabilitation undertaken; in accordance with the National Environmental Management Act, 1998 and the Environmental Impact Assessment Regulations, 2014; ➢ a description of the methods to decommission each prospecting or mining component and the mitigation or management strategy proposed to avoid, minimize and manage residual or latent impacts; ➢ details of any long-term management and maintenance expected;

Regulation	Requirements
	➢ details of a proposed closure cost and financial provision for monitoring, maintenance and post closure management; in accordance with the National Environmental Management Act (Act No. 107 of 1998) and the Environmental Impact Assessment Regulations (2014), as amended; ➢ a sketch plan drawn on an appropriate scale describing the final and future land use proposal and arrangements for the site; ➢ a record of interested and affected persons consulted; and ➢ technical appendices, if any.

7.4.3 National Environmental Management Act (Act No. 107 of 1998)

Prior to 8 December 2014, the environmental aspects of mining and production activities were regulated in terms of the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002). Recent legislative amendments and the drive towards a 'one environmental system' have resulted in the inclusion of the requirement for rehabilitation, decommissioning and closure planning and associated financial provisions into the NEMA. Specific sections of the Act are extracted below:

Section 24P: Financial provision for remediation of environmental damage:

1. An applicant for an environmental authorisation relating to prospecting, exploration, mining, or production must, before the Minister responsible for mineral resources issues the environmental authorisation, comply with the prescribed financial provision for the rehabilitation, closure, and ongoing post decommissioning management of negative environmental impacts.
2. If any holder or any holder of an old order right fails to rehabilitate or to manage any impact on the environment or is unable to undertake such rehabilitation or to manage such impact, the Minister responsible for mineral resources may, upon written notice to such holder, use all or part of the financial provision contemplated in subsection (1) to rehabilitate or manage the environmental impact in question.
3. Every holder must annually (a) assess his or her environmental liability in a prescribed manner and must increase his or her financial provision to the satisfaction of the Minister responsible for mineral resources; and (b) submit an audit report to the Minister responsible for mineral resources on the adequacy of the financial provision from an independent auditor.
    (a) If the Minister responsible for mineral resources is not satisfied with the assessment and financial provision contemplated in this section, the Minister responsible for mineral resources may appoint an independent assessor to conduct the assessment and determine the financial provision. (b) Any cost in respect of such assessment must be borne by the holder in question.
4. The requirement to maintain and retain the financial provision contemplated in this section remains in force notwithstanding the issuing of a closure certificate by the Minister responsible for mineral resources in terms of the Mineral and Petroleum Resources Development Act, 2002 to the holder or owner concerned and the Minister responsible for mineral resources may retain such portion of the financial provision as may be required to rehabilitate the closed mining or prospecting operation in respect of latent, residual or any other environmental impacts, including the pumping of polluted or extraneous water, for a prescribed period.

5. The Insolvency Act, 1936 (Act No. 24 of 1936), does not apply to any form of financial provision contemplated in subsection (1) and all amounts arising from that provision.

(7) The Minister, or an MEC in concurrence with the Minister, may in writing make subsections (1) to (6) with the changes required by the context applicable to any other application in terms of this Act.

Section 24R: Mine closure on environmental authorisation:

1. Every holder, holder of an old order right and owner of works remain responsible for any environmental liability, pollution or ecological degradation, the pumping and treatment of polluted or extraneous water, the management and sustainable closure thereof notwithstanding the issuing of a closure certificate by the Minister responsible for mineral resources in terms of the Mineral and Petroleum Resources Development Act, 2002, to the holder or owner concerned.
2. When the Minister responsible for mineral resources issues a closure certificate, he or she must return such portion of the financial provision contemplated in section 24P as the Minister may deem appropriate to the holder concerned but may retain a portion of such financial provision referred to in subsection (1) for any latent, residual or any other environmental impact, including the pumping of polluted or extraneous water, for a prescribed period after issuing a closure certificate.
3. Every holder, holder of an old order right or owner of works must plan, manage, and implement such procedures and requirements in respect of the closure of a mine as may be prescribed.
4. The Minister may, in consultation with the Minister responsible for mineral resources and by notice in the Gazette, identify areas where mines are interconnected or their impacts are integrated to such an extent that the interconnection results in a cumulative impact.
5. The Minister may, by notice in the Gazette, publish strategies in order to facilitate mine closure where mines are interconnected, have an integrated impact, or pose a cumulative impact.

7.4.4 Financial Provisioning Regulations (2015)

However, for completeness sake, the section below describes the applicable sections of the Financial Provision Regulations (2015). It must be noted that the Minister has extended the implementation date of these regulations to 23 September 2023. At this date all operations with existing rights and permits will need to comply within three months of the Holders' financial year ends.

On 20th November 2015, the Minister promulgated the Financial Provisioning Regulations under the NEMA (GN R1147). The regulations (as amended) aim to regulate the determining and making of financial provision as contemplated in the NEMA for the costs associated with the undertaking of management, rehabilitation and remediation of environmental impacts from prospecting, exploration, mining or production operations through the lifespan of such operations and latent or residual environmental impacts that may become known in the future. These regulations provide for, *inter alia*:

- Determination of financial provision: An applicant or holder of a right or permit must determine and make financial provision to guarantee the availability of sufficient funds to undertake rehabilitation and remediation of the adverse environmental impacts of prospecting, exploration, mining or production operations, as contemplated in the Act and to the satisfaction of the Minister responsible for mineral resources.
- Scope of the financial provision: Rehabilitation and remediation; decommissioning and closure activities at the end of operations; and remediation and management of latent or residual impacts.
- **Regulation 6**: Method for determining financial provision – An applicant must determine the financial provision through a detailed itemisation of all activities and costs, calculated based on the actual costs of implementation of the measures required for:
  - Annual rehabilitation – annual rehabilitation plan;
  - Final rehabilitation, decommission and closure at end of life of operations – rehabilitation, decommissioning, and closure plan; and
  - Remediation of latent defects and residual impacts – environmental risk assessment report.
- **Regulation 10:** An applicant must -
  - ensure that a determination is made of the financial provision and the plans contemplated in regulation 6 are submitted as part of the information submitted for consideration by the Minister responsible for mineral resources of an application for environmental authorisation, the associated environmental management programme and the associated right or permit in terms of the Mineral and Petroleum Resources Development Act, 2002; and
  - provide proof of payment or arrangements to provide the financial provision prior to commencing with any prospecting, exploration, mining, or production operations.

- **Regulation 11**: Requires annual review, assessment, and adjustment of the financial provision. The review of the adequacy of the financial provision including the proof of payment must be independently audited (annually) and included in the audit of the EMRr as required by the EIA regulations.

Appendix 4 of the Financial Provisioning Regulations provides the minimum content of a final rehabilitation, decommissioning, and closure plan. This final rehabilitation, decommissioning and closure plan has been prepared to align with these requirements. Appendices 3 and 5 of the Financial Provisioning Regulations provide content requirements for the Annual Rehabilitation Plan and Environmental Risk Assessment Report, respectively.

7.5 Closure vision, objectives and targets

The vision, and consequent objective and targets for rehabilitation, decommissioning, and closure, aim to reflect the local environmental and socio-economic context of the project, and to represent both the corporate requirements and the stakeholder expectations as well as the legislative framework and regulations.

The receiving environment within which the exploration and production activities are being undertaken include the following key land-uses:

- Agriculture- cultivated fields;
- Natural and degraded veld primarily utilised or livestock grazing; and
- Mining right areas

In addition, the stakeholders consulted during the public participation process for the EIA raised concerns regarding, amongst others, the following:

- Impacts on ground water quality and availability;
- Impacts on surface water quality;
- Disruption of current land use and capability;
- Sense of place;
- The quantum for rehabilitation; and
- Security and access to individual farms.

With reference to both the environmental context of the project and the feedback from the consultation process the vision for closure is to:

Ensure that the landscape is safe, stable and non-polluting over the long-term, and that the post-closure land use aligns with the surrounding land use and does not affect the sustained utilisation thereof.

In support of achieving this post-closure vision there are certain key rehabilitation, decommissioning, and closure objectives. Well-conceptualised rehabilitation objectives will allow assessment of the risks associated with achieving these objectives and guide the setting of sustainable rehabilitation actions to be taken to mitigate these risks at every stage of the exploration process. Rehabilitation objectives describe "what" needs to be achieved to reach the mine's rehabilitation goal. These objectives must be aligned to the site-specific characteristics that are within the right holder's control. Rehabilitation objectives should be as specific, measurable, achievable, and realistic as possible. They must also define a time period against which they can be "measured".

Guided by the closure vision, and with due consideration of the project context the following closure objectives and associated targets are presented in Table 7-3.

Table 7-3: Closure objective and associated targets

Objective	Target
Set the course for eventual ecosystem rehabilitation, including the improvement of natural vegetation community (where applicable), hydrology, and wildlife habitats for impacted areas only	Alignment of soil condition with that required to meet the defined land capability commitments. Sustainable natural areas. Agreed upon viable land use(s)
Prevent future environmental issues related to long term fluid or gas leakage or vertical movement through the wells	No migration of gas or water along the rehabilitated well bore.
Protection of water resources	Consistent with baseline condition (specifically production indicator parameters).
Ensure that land is usable, in alignment with surrounding land uses.	Agreed upon viable land use.

7.6 Alternative closure and post-closure options

Several alternative closure and post-closure options are available. The identification and consideration of the most suitable alternatives are guided by, *inter alia* the following considerations:

The ability of the selected alternative to adequately meet the specified closure vision and objectives.

- The efficiency, viability, and practicality of the selected alternative.

- The preference, where possible, for low maintenance and sustainable options.
- The alignment with the local environmental and socio-economic context and associated opportunities and constraints.

The possible available options and alternatives that are related to the rehabilitation and closure process are presented in Table 7-4. The options in the table that are marked in GREEN are considered to be the preferred options for the purposes of the final rehabilitation, decommissioning and closure plan. It is important to note that as new alternatives become available for the rehabilitation, decommissioning and closure of oil and gas wells, this plan can be reviewed to make provision for these.

Table 7-4: Closure alternatives

Project feature	Aspect	Options	Pros	Cons	Comment
Exploration wells	Casing	**Retain casing**	No additional effort, time, and cost to remove the casing string. The casing and associated cemented annulus may provide an additional barrier and stability to the well.	Depending on the nature of the well, corrosion of the casing over time may affect the integrity of the plug.	It is suggested that the casing is retained and that industry standard well bore plugging and abandonment be implemented.
		Remove casing	Casing is often removed in an attempt to recover and salvage the steel.	The retention of the casing is strongly dependent on the nature of the geological strata and location of the groundwater aquifer and other permeable zones. The presence of these zones may also be a hindrance to the removal of a casing string. Removal of the casing string may result in the collapse of the well making controlled plugging difficult/impossible.	
Exploration wells	Plugging extent – the primary objective of wellbore plugging is to isolate potential flow zones (including gas and water zones).	**Plugging full length of well bore.**	Provides longer barrier distance.	Additional design and implementation costs.	

Project feature	Aspect	Options	Pros	Cons	Comment
		Partial / intermittent plugging of well bore.	Reduce design and implementation costs.	Reduce barrier length may result in opportunity for fluid or gas migration.	As a standard the well bore will be cemented for the full length and diameter of the well bore to surface. There may be instances where intermittent plugging options are preferrable – in such instances, these deviations must be designed and reviewed by a well engineer and approved by the competent authority.
Exploration wells	Plugging material	**There are various materials available for a barrier including (chemical, natural, and mechanical). The barrier can be a single or multicomponent system and should aim to have the following properties:** • **Inability for well fluids to pass;** • **No degradation of sealing capacity over time;** • **Avoidance of movement; and** • **Appropriate of the specific environment and application.**	There are different advantages and disadvantages for the different types of barrier materials. The specific environmental circumstances and the nature of the well construction will dictate which barrier is most appropriate.		The cement to be used must comply with industry best practices and relevant API standards, or alternative standards as agreed with the relevant authority and as approved by a well engineer. It is also recommended that a well bore stress model is developed and applied to the well(s) to predict the long term thermal and mechanical stresses and adapt the plug material accordingly.

Project feature	Aspect	Options	Pros	Cons	Comment
Exploration wells	Plugging techniques and barrier placement methodology.	**Squeeze / displacement method: This method may include, balanced plugs, pump and pull, perforation, wash, and cement, inside blowout preventer, and sacrificial work-string release tools.**	The displacement method minimises the contamination of the cement by being able to displace fluid within the well, which allows for a more stable plug.		The specific type of displacement method to be utilised is depending on the well construction and alignment as well as the prevailing hydrostatic balance.
		Dump Bailer – typically used to deliver a small volume of cement.	Allows for accurate control of plug placement depth.	Outdated. This technique has the potential to allow for contamination of the well plug and therefore may affect the plug integrity. Only allows for limited cement volume per placement.	
Exploration wells	Well surface infrastructure – this includes the well head, plinth, electrical components, and fencing (where relevant).	**Complete removal**	Allows for complete site decommissioning and rehabilitation. Allows for future unhindered alternative land use(s).	Additional costs	The surface area of a decommissioned well must be clear of obstructions and equipment. In order to allow unhindered land use of the well area, it is suggested that all surface infrastructure (up to 1m below ground) be removed. In addition, the well will be capped at approximately 1m below ground level with the requirement for marking its' location and representing its' position on the Title Deed / SG Diagram.
		Retain	Potential for landowner to retain for alternative use(s).	Risk of future liability for rights holder. May hinder future land use(s).	

Project feature	Aspect	Options	Pros	Cons	Comment
Testing facility and associated infrastructure	All surface infrastructure including access roads, power and water supply.	**Complete removal**	No remnant liability associated with surface infrastructure.	Additional costs	Allowance is made in the current final rehabilitation, decommissioning and closure plan to decommission, demolish and dispose of the testing facility and associated infrastructure and rehabilitate the area. Although no discounting can be done in terms of Government Notice R1147, the possibility exists to either sell off the components of the infrastructure or to treat them as assets that can be dismantled, transported and reassembled where required.
		Retain	Provides an opportunity for infrastructure to be reused or repurposed either in full or partially. Allows for alternative post-closure options.		
Access roads	All project roads	**Rehabilitate**	No remnant liability associated with maintenance or ownership of access roads. Allows for returning the area to pre-commencement land use(s).	Additional cost	The intention is to rehabilitate the area, including the access routes, to the pre-construction condition. However, in certain instances, the landowner may request the retention of the access route(s). The applicability of these options will need to be addressed on a case-by-case basis prior to closure.
		Retain	Allows for reuse or repurposing if there is a need for such. Reduce costs	Long term degradation of the roads might lead to post-closure liabilities for the right holder.	

7.7 Motivation for preferred closure options

With reference to the above, the preferred closure options is as follows:

- Retain casing (informed by a pre-closure inspection of casing integrity) and plug using a displacement/pump/squeeze technique, the full length of the well with a suitable plugging cement, as prescribed by industry best practice, and in accordance with the applicable API guidelines and standards as signed off by a well engineer and agreed to by PASA.
- Cut surface casing at a depth below surface to be informed by end land-use (presumed below plough depth), remove and bury.
- Allowance is made for full decommissioning, demolition and disposal of the exploration infrastructure after closure as well as rehabilitation of the site.
- Rehabilitate access routes or retain when requested by a landowner.

It is anticipated that the closure options presented above, together with monitoring over a 1-year post closure period, will achieve the stipulated closure objective. This closure option is in line with industry best practice and the requirements of the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002).

Effective abandonment depends on knowledge of the well construction, geology, and the hydrogeology. In this regard it is recommended that prior to commencement of closure and decommissioning of any specific well the following must be undertaken:

- A detailed site-specific decommissioning plan must be prepared by an appropriately qualified specialist or specialists. This plan must take into consideration the following site-specific factors:
    - Current condition and design of the well (informed by suitable well integrity testing);
    - Records of the drilling results, cement used and testing results for the life of each well, including the cement bond log tests immediately after grouting and prior to decommissioning as well as any periodic maintenance checks during the operational life;
    - Height of cement in annulus outside casing;
    - Considerations for the composition and placement of the plug or barriers should include:
        - Location of potential flow zones and pore pressures.
        - Location of useable water sources.

- Formation fracture pressure of natural seals.
- Cross flow potentials; direction and resultant equalised pressures.
- Future field plans.
- Compaction, subsidence, and recharged formations.
- Corrosion risks.
- Locations of natural faults and their ability to transmit fluids and/or pressure.
- Ability to be able to verify the barrier.
- Operating environment (temperature, pressures, chemical characteristics).

- Cement casing overlaps;
- The need for abandonment plugs to cover the full diameter of the hole;
- The type of fluid in annuli above cement;
- The chemical composition of the prevailing groundwater;
- The following considerations apply to determining the composition of the barrier material/s:
  - Inability for wellbore fluids to bypass in either direction.
  - No degradation of sealing capacity over time. The specific host rock thermal and effective stress characteristic which may affect permanent plug integrity.
  - Avoidance of movement.
  - Appropriate for the environment (e.g. Temperature, pressure, chemical exposure) and application.
- Potential difficulties of injecting cement into the annulus;
- Future monitoring of the integrity of the well plug; and
- The depth below surface at which casing must be cut.

- The applicable landowner must be consulted, and input obtained regarding the current and planned land-uses applicable to the area and the need to retain surface infrastructure, well accessibility and/or access tracks.

The revised decommissioning plan and the feedback from the landowner consultation must be submitted to the PASA prior to implementation. Table 7-5 provides a list of threats, opportunities and uncertainties related to the preferred closure options.

Table 7-5: Threats, opportunities, and uncertainties associated with preferred closure option

Item	Descriptions
Threats	Insufficient financial provision to adequately implement closure plan. Insufficient management commitment to effective rehabilitation. Inadequate topsoil management during exploration phase to allow for adequate topsoil cover to enable rehabilitation. Inability to identify and implement a suitable alternative land use on the defined alternative land use areas. Groundwater modelling inaccurately predicts the potential medium to long term impacts on the groundwater resources. Incorrect plug/ barrier materials used for well bore plugging could result in long term degradation of plug effectiveness. Third party activities may affect the success of the rehabilitation and closure strategies (e.g. ongoing mining activities such as blasting, and excavations may impact on the long term integrity of well barriers and casing). Movement of faults which may intersect the zone of influence of a well may compromise the long-term stability of the barrier or casing.
Opportunities	The NEMA requires annual review of the rehabilitation and closure plans and associated financial provisions - this provides an ideal opportunity to ensure that the rehabilitation process is assessed for relevance on a continual basis.
Uncertainties	There are certain closure actions and parameters which are uncertain prior to actual closure. These include the status of the well bores at the time of closure. The specific circumstances will need to be assessed at the time of closure by a qualified well engineer and a decommissioning plan prepared. The extent to which the infrastructure established for the exploration may be of value for reuse or repurposing by the landowners is uncertain at this stage and must be ascertained prior to final closure. The groundwater model should continue to be updated based on monitoring data and the predictions of impacts to water resources should be reviewed and revised. An adaptive land management approach will be adopted on-site, allowing for implementation of alternative and improved rehabilitation strategies and corrective action, where required.

7.8 Closure period and post-closure requirements

The closure period is defined as the period between the cessation of exploration, and the completion of active rehabilitation actions on the applicable site. It may become necessary to decommission and plug unsuccessful or dry wells during the exploration phase. In these instances, it is suggested that closure on these specific wells is initiated as soon as possible.

Following successful completion of the active closure actions it is suggested that a further post closure period be assigned to allow for monitoring of the success of closure. This closure and post closure monitoring will involve the following actions and durations:

- Water monitoring - as informed by the water monitoring plan for 2 years after decommissioning or until a long-term trend can be determined;
- Fugitive gas emissions using either soil vapour probes, effluxes, or surface methanometers, for a period of 2 years post closure;
- Well plugging and abandonment verification to confirm that there is proper and effective vertical isolation (this could include: bond log tests, cementing tests, communication tests, hydraulic pressure tests, applied weight test); and

It is noted that since all the well locations are in previously disturbed areas (agricultural fields) that have no biodiversity significance prior to exploration, no provision has been made for any biodiversity monitoring post-closure.

There are however certain residual and latent impacts which may manifest in the post closure phase. These relate primarily to the risk of well plug integrity and associated long-term management of vertical migration of gas and/or fluids to the shallow water resources or the surface.

8 ENVIRONMENTAL INDICATORS AND MONITORING

A list of environmental impacts identified for the rehabilitation, decommissioning, and closure of the project is provided in Table 8-1. In addition, environmental indicators are identified for each impact, together with proposed monitoring requirements. The indicators and monitoring will aim to inform ongoing rehabilitation and remediation activities. These indicators will also inform the assessment of whether the closure objectives have been adequately met.

Table 8-1: Environmental Indicators and Monitoring requirements

Aspect	Impact	Monitoring requirement	Indicators	Closure targets
Social	Potential to use local service providers and contribute directly to local economy.	None	Complaints register	No unaddressed issues.
	Interruption in services.	Regular monitoring and reporting (monthly Environmental Control Officer (ECO) reports) during decommissioning.		
	Interference with existing land uses.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.		
	Impacts on existing services and infrastructure.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.		
	Re-instatement of access routes give access to land/infrastructure that was cut off by the project.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.		
	Increase in social license to operate due to management of nuisance impacts.	Community Liaison Forum held twice a year during construction and operational phases. Pre-decommissioning and closure forum with relevant affected landowners.		

Aspect	Impact	Monitoring requirement	Indicators	Closure targets
	Impacts on safety and security of local residents due to presence of unfamiliar people in the area.	As part of the monthly ECO reports, the impact of safety and security must be assessed and reported on.		
	Public perceptions about the impact of decommissioning on the sense of place.	Community Liaison Forum held twice a year during construction and operational phases. Pre-decommissioning and closure forum with relevant affected landowners.		
Economic	Alternative land-use.	As per the environmental risk assessment conducted in Section 6, all the significant enhancement measures are legislated, and these measures are currently monitored by various responsible government departments. No enhancement measures over and above to what is prescribed by the mining charter, B-BBEE codes and the Social and Labour Plan, is advised.	N/A	N/A
	Black economic transformation.		N/A	N/A
	Country and industry competitiveness.		N/A	N/A
	Economic development per capita.		N/A	N/A
	Employment impacts.		N/A	N/A
	Fiscal income.		N/A	N/A
	Forex savings.		N/A	N/A
	GGP impact.		N/A	N/A
	Need and desirability.		N/A	N/A

Aspect	Impact	Monitoring requirement	Indicators	Closure targets
Air quality	Fugitive emissions (dust) from decommissioning/ removal of all berms, trenches and other stormwater infrastructure no longer required.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Evidence of excessive dust Generated (complaints).	No dust nuisance complaints.
	Greenhouse gas emissions from decommissioning/ removal of stationary infrastructure.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Natural gas concentrations.	No fugitive emissions from wells.
	Fugitive emissions (dust) from decommissioning/ removal of stationary infrastructure.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Evidence of excessive dust generated (complaints).	No dust nuisance complaints.
	Greenhouse gas emissions from the removal of waste and recycling of recyclable / reclaimable waste.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Natural gas concentrations.	No fugitive emissions from wells.
	Fugitive emissions (dust) from the removal of waste and recycling of recyclable / reclaimable waste.	Regular monitoring and reporting (monthly ECO reports) during decommissioning.	Evidence of excessive dust generated (complaints).	No dust nuisance complaints.
	Contamination of alluvial and sand aquifers.	Regular monitoring and reporting (monthly ECO reports) during decommissioning. An emergency response protocol must be implemented that is aimed at early detection and swift reaction speed relating to leaks and spills.	Groundwater quality	Consistent with baseline condition (specifically production indicator parameters).

Aspect	Impact	Monitoring requirement	Indicators	Closure targets
	Contamination from leakage and spillage.	Monitoring should take as per the EMPR requirements.	Groundwater quality	Consistent with baseline condition (specifically production indicator parameters).
Hydrogeology	Stray gas migration affecting groundwater quality.	Monitoring should take as per the EMPR requirements.	Groundwater quality	To be kept consistent with baseline condition.
	Well casing and/or cementation failure affecting groundwater quality.	Monitoring should take place for 50 years after cessation of production activities or until a long-term acceptable trend can be determined. A groundwater and gas monitoring programme will be implemented to serve as an early detection mechanism.	Groundwater quality and natural gas concentrations.	Consistent with baseline condition (specifically production indicator parameters) and no fugitive emissions from wells.
	Potential to use local service providers and contribute directly to local economy.	None	N/A	N/A
	Impacts on safety and security of local residents due to presence of unfamiliar people in the area.	Appointment of a Community Liaison Officer and regular monitoring and reporting (monthly ECO reports) during closure and rehabilitation.	Complaints register	No unaddressed issues

Aspect	Impact	Monitoring requirement	Indicators	Closure targets
Social	Interference with existing land uses/livelihoods.	Appointment of a Community Liaison Officer and regular monitoring and reporting (monthly ECO reports) during closure and rehabilitation.	Complaints register	No unaddressed issues
	Increase in social licence to operate due to management of nuisance impacts.	Appointment of a Community Liaison Officer and regular monitoring and reporting (monthly ECO reports) during closure and rehabilitation.	Complains register	No correlated increased levels of methane on underground workings.
	Plugged wells resulting in redistribution of gas to underground workings.	Records of consultation with the affected mining entities.	Minutes of meetings	Alignment with adjacent reference site or pre-commencement condition.
	Degradation of natural habitat- including erosion and alien invasives. Should rehabilitation not be successful then there is a potential for degradation of the rehabilitated surface and adjacent areas.	Visual inspections of rehabilitated areas.	Presence of erosion features. Presence of alien invasive species.	Alignment with adjacent reference site or pre-commencement condition.
Biodiversity				

9 FINAL CLOSURE LAND USE

The ultimate aim of most closure and land rehabilitation is to return the land to the same or similar state to what it was pre-exploration. In order to inform this target it is important to have a clear understanding of what the pre-exploration land-use and land capability was.

Land-use is the way land is used by people for a defined purpose and may comprise one or more land uses. In most instances, one landscape can support numerous land-uses within the constraints of land capability, creating a multifunctional landscape.

The main economic activities within the exploration right area relate to farming (livestock/ game grazing and cultivated lands) and mining (primarily gold mining). The final post closure land-use will depend on the specific site circumstances, in so far as it relates to the pre-exploration uses and also the prevailing uses, at the time of closure. It is therefore proposed that, prior to initiating closure, a suitably qualified environmental scientist undertake an assessment and consult with the landowner and prepare a site-specific decommissioning plan for submission to PASA for review and approval. For the purposes of this final rehabilitation and closure plan it is assumed that the post closure land use will be congruent with the agricultural and natural veld mix of land-use and capability in the region.

9.1 Closure actions

In order to align with the defined closure plan and final land-use objectives, the exploration right holder will need to implement a series of actions which addresses the infrastructure, facilities, and rights area, as well as ongoing maintenance and management thereof. These actions and obligations apply to all infrastructure, activities, and aspects both within the exploration right area over which the holder has responsibility.

The anticipated closure actions can be summarised as follows:

- Phase 1: Preparation for closure.
- Phase 2: Making safe.
- Phase 3: Rehabilitation.
- Phase 4: Monitoring and maintenance.

The detailed closure actions are presented in the sections below.

9.1.1 Phase 1: Preparation for closure

9.1.1.1 General activities

There are certain closure actions that are required to be initiated and, in some instances, concluded prior to finalising and implementing the eventual decommissioning, rehabilitation and closure of the activities. The preparatory actions include the following:

- Ensure that the final rehabilitation, decommissioning and closure plan and Risk Assessment is up to date and approved.
- Application for Environmental Authorisation, Waste Management Licence and/or Water Use Licence (if applicable to implement closure plan) for decommissioning and closure activities (at least 18 months prior to scheduled closure).
- Pre-emptive planning for post closure land-use including development of surface infrastructure inventory and the identification of infrastructure which is available for reuse and repurposing post closure.
- Develop or continue with local stakeholder and public communication forum/ mechanisms to communicate rehabilitation progress and facilitate grievances.
- Engage with local stakeholders and specifically the directly affected landowner to reaffirm the final closure strategy- for instance there may be instances where a landowner may wish to retain or repurpose certain infrastructure.
- Update material and topsoil balances to confirm availability of suitable material for rehabilitation.
- The need for, and extent of, and active revegetation will be determined during the initial site assessment as well as the pre-closure site assessment.
- Ensure that a comprehensive alien vegetation eradication, control and management plan is in place.
- Ensure that applicable sensitive areas and stockpiles are suitably identified and demarcated and the water and waste management plans are up to date (including inventories of waste sources, storage and eventual disposal options).

These actions apply primarily to the surface infrastructure not directly associated with the wells.

9.1.1.2 Preparation for well decommissioning and closure

A well that is no longer been monitored during exploration, or for which an approved suspension period has passed, must be plugged and decommissioned in accordance with an approved decommissioning plan. The following tasks will be undertaken prior to decommissioning:

- Site inspection and assessment by a suitably qualified environmental professional with the aim to:

- Confirm pre-closure site conditions.
- Undertake a site-specific closure risk assessment.
- Consult with the affected landowner to confirm closure land use.

- Site inspection by a suitably qualified specialist/s to:
  - Assess the conditions of the specific well in respect of inter alia:
    - Current condition and design of the well; and
    - The integrity of the casing and grouting;
  - Determine the most suitable and appropriate decommissioning strategy with specific focus on the plugging method (including plug dimensions and plugging materials to be used) to ensure no vertical gas and/or fluid movements within the well.
- Preparation of a consolidated site-specific closure and decommissioning plan.

The site-specific closure and decommissioning plan will be submitted to the PASA for review and approval prior to initiating closure.

9.1.2 Phase 2: Closure and rehabilitation

An indication of typical closure and rehabilitation actions that should be followed are provided in Table 9-1.

Table 9-1: Summary of typical closure actions

Component	Closure action
Dismantling and removal of any on site infrastructure from well sites.	• Pre-emptive planning for post closure land-use including development of surface infrastructure inventory and the identification of infrastructure which is available for reuse and repurposing post closure. • Removal of all services, structures, machinery, and infrastructure unless these are specifically required for post-exploration land-use, post-exploration projects or have been requested by the landowner. • Establish formal agreements for any infrastructure handed over for third party use, and management. • All identified infrastructure should be broken down to natural ground level. All waste materials to be disposed of at suitably licenced disposal facilities. • Dismantle and dispose of all fences that do not form part of post-closure property boundaries. • Areas where infrastructure was demolished should be assessed through a risk-based system to determine if there is any residual contamination or risk and appropriate remediation measures implemented. Where contaminated material is detected, this should be removed and disposed of.

Component	Closure action
	• Profile the area to be free draining. • Remove and rehabilitate all Stormwater management infrastructure not required in the final closure plan. • Assess available topsoil stockpiles in respect of quantity and quality the topsoil's to be placed for rehabilitation must be suitable for revegetation. • Revegetate disturbed areas with suitable local grass mix in areas where natural regrowth is not successful of anticipated. • A waste and infrastructure hierarchical principal should be applied to all decommissioned infrastructure or wastes, as follows: Reduce, reuse, recycle, dispose. • Manage dust generated from decommissioning activities to relevant standards. • Removal and safe disposal of evaporation ponds/ dams. • Ongoing monitoring to ensure vegetation regrowth, no erosion and no alien and invasive plant establishment..
Rehabilitation of access roads	• Develop rehabilitation phase traffic/ transport layout plan to utilise existing access routes where possible and minimise unnecessary access roads. • Restrict vehicular movements to designated access and routes to avoid unnecessary soil compaction. • Conclude final closure layout plan defining access roads required for ongoing monitoring, management, and maintenance. • Remove access roads with no beneficial re-use potential by deep ripping, shaping and levelling after the removal and disposal of any culverts, drains, ditches and/or other infrastructure. Natural drainage patterns are to be reinstated. • Retained access roads to be designed in accordance with relevant engineering standards and specifications- including specific management of stormwater. • Closure, decommissioning, and rehabilitation of all access roads (incl. associated structures, signage, culverts, etc) unless these are specifically required for post-closure land-use, post-closure projects, or have been requested by the landowner. • Remove any contaminated soil from roads, dispose at suitably licenced facilities. • Deep rip all compacted areas prior to rehabilitation. • Topsoil rehabilitation and amelioration as is necessary. • Revegetation. • Apply dust suppression (e.g. water sprays) where necessary.
Well site	• The borehole must be cleared of obstructions prior to abandonment. This includes associated surface infrastructure. • Remove any waste materials from the well sites and dispose at a suitably licenced waste disposal facility.

Component	Closure action
	• Prior to placing plugs- the state and effectiveness of the applicable annular barrier must be evaluated and verified (method may include cement bond logs, calliper logging, or communication tests). Where necessary this may require remediation of this annular barrier prior to plugging. • Suitably qualified specialist or specialists to design the most suitable and appropriate closure strategy to ensure no vertical gas or fluid movements and that all potential hydrocarbon / water bearing formations by utilizing placed cement plugs. This must include determination of plug length/ location and plug material specifications. • Cementing of the wells will be conducted for the entire length of the wellbore (both in the open hole as well as the upper casing) to ensure efficient redundancy. The extent of plugging to be confirmed during the Preparation phase. • All plugs are tagged to ensure successful placement. • Cementation technique to follow the squeeze displacement technique (or alternative as directed by the well engineer). Wiper plugs must be utilised where applicable. • Conduct cement top-ups along the annulus, and existing cemented sections showing “no bond” or “poor bond” from logging results. • The integrity and effectiveness of the plug must be evaluated and verified once completed. There are many evaluation and verification methods which can be used subject to a specific well circumstance (e.g. physical or mechanical tests, or hydraulic/ pressure tests). The most suitable verification method to be determined by a suitably qualified well engineer. • A surface / shallow cement plug (+/-50m below ground Level) is set, and the well is cut and capped +/-1m below ground level to remove the wellhead and all casing above this point. • The cellar is then collapsed and the surface reinstated and the site rehabilitated. • Rehabilitation must reflect the local environment -ecosystem rehabilitation of impacted areas, including natural fauna and flora, hydrology and hydrogeology. • Ensure that than the final landscape is safe, stable and non-polluting over the long term, and that post closure land-use does not affect the sustained utilization. • Placement of a “surface tag” in order to ensure monitoring can continue once the casing is cut and the area revegetated.
General surface rehabilitation	• Develop and implement an alien vegetation eradication control and management plan. • The removal and/or disturbance of previously unaffected topsoil’s must be avoided as far as possible and limited to the existing areas of disturbance. • Develop and implement a revegetation plan. Seeding and planting to be done at, or immediately after, the first rains in spring, and into freshly prepared, fine-tilled seedbeds (where soils are not prone to crusting). • Annual monitoring of the status of rehabilitation and revegetation.

Component	Closure action
	• No driving will be permissible on any rehabilitated areas- only on predefined designated routes for monitoring. • Implement soil amelioration as is necessary. • Any contamination of the topsoil on surrounding areas must be avoided by ensuring machinery is well maintained and leak free. If contamination has occurred, the area must be remediated and ameliorated immediately. • Monitoring, including review and assessment of soil balances, soil surveys (stripped, stockpiles, and placed). • Implement defoliation on established grasses and vegetation under direction of rehabilitation specialist- to allow for reintroduction of organic matter. • Ongoing rehabilitation monitoring (including soil surveys) and maintenance until relinquishment. • Ongoing rehabilitation of eroded areas through a root cause investigation and rectification approach. • Shape all channels and drains (where applicable) to smooth slopes and integrate into the natural drainage pattern. • Construct contour banks and energy dissipating structures as necessary to protect disturbed areas from erosion prior to stabilisation. • Implement controlled livestock grazing once vegetation is established. Restrict access of livestock newly rehabilitated unless specifically required for defoliation as instructed by a suitably qualified rehabilitation specialist. • Ongoing rehabilitation monitoring and maintenance until relinquishment. Including but not limited to: Alien invasive monitoring and management, erosion control and remediation, vegetation growth and supplementation).
Social and economic change management	• Regular consultation with interested and affected parties on closure planning and rehabilitation progress, and any intrusive activities. • Develop final land management and maintenance plan with relevant landowners. • Implement land management and maintenance plan.

9.1.3 Phase 3: Monitoring, maintenance and relinquishment

The purpose of monitoring is to ensure that the objectives of the rehabilitation and closure plan are met. In this regard the following actions, to be adjusted based on the completion of the pre-closure site assessment, are proposed:

- **Groundwater monitoring (exploration wells):** The post-closure groundwater quality and yield monitoring should take place for 2 years or until a long-term acceptable trend can be determined. The extent of the monitoring is to be determined in the site-specific closure and decommission plan (provision has been made for annual monitoring). The aim of this monitoring is to confirm that abandoned wells are safe and are not resulting in a pollution hazard.
- **Flora (all areas):** Biodiversity assessments mid wet season should be undertaken by a qualified ecologist / botanist to monitor the rehabilitation progress with regards to flora. Confirmation that acceptable cover has been achieved in areas where natural vegetation is being re-established. “Acceptable cover” means re-establishment of pioneer grass communities over the disturbed areas at a density similar to surrounding undisturbed areas, non-eroding and free of invasive alien plants.
- **Gas emissions (production and exploration wells):** The well site must be monitored for the release of gas from the decommissioned well site. This can be undertaken through appropriate sampling techniques, either soil vapour probes, effluxes, or surface methanometers.

Annual (or as agreed with PASA) environmental reports will be submitted to the PASA and other relevant stakeholders for at least 1-year post-decommissioning (phase 3). The monitoring reports shall include a list of any remedial action necessary to ensure that infrastructure that has not been removed remains safe and pollution free and that rehabilitation of project sites are in a stable, weed and free condition. Electronic/digital photographs will be taken before and after rehabilitation.

9.2 Final rehabilitation, decommissioning and closure schedule

This section presents a high-level list of rehabilitation and closure components and the key actions related to the final rehabilitation, decommissioning, and closure. The key schedule drivers for each activity are presented in Table 9-2. It is important to note that there are potentially permits and licences which may be required prior to initiating closure activities these may include water use licences and/or environmental authorisations. These should be initiated as soon as practically possible as the timeframes for these processes can be extensive.

Table 9-2: Closure schedule drivers

Activity	Closure schedule driver
Ongoing activities	Ongoing progressive rehabilitation as exploration progresses (specifically post-abandonment of unsuccessful wells and well site laydown areas). Ongoing decommissioning and closure of abandoned exploration wells. The timing of this will depend on when a decision is made to abandon a specific well.
Planning and preparation for Closure	Updated final rehabilitation decommissioning and closure plan and compliance with the Financial Provision Regulations.

Activity	Closure schedule driver
	Obtain relevant closure related environmental authorisations, licences, and permissions (if applicable).
Dismantling and removal of any on site infrastructure	Progressively as infrastructure is no longer required. Final dismantling of all infrastructure not to be retained at cessation of exploration activities.
Rehabilitation of access roads	Cessation of exploration activities and where relevant rehabilitation activities- if possible rehabilitation of access roads should be done progressively as these roads are no longer required.
Decommissioning and closure of well sites	Well decommissioning and plugging will be initiated once a well site is no longer useful for exploration purposes or lapsing of the approved exploration period. The closure will commence on completion and approval of the site-specific decommissioning plan.
Removal and safe disposal of exploration wastes.	Completion of decommissioning.
General surface rehabilitation	Completion of decommissioning. Seeding and planting is most successful when done at or immediately after the first rains in spring, and into freshly prepared, fine-tilled seedbeds (where soils are not prone to crusting).
Rehabilitation Monitoring	Ongoing throughout rehabilitation activities and into the closure and post closure periods.
Social and economic change management	Ongoing throughout rehabilitation activities and into the closure period.

9.3 Organisational capacity

It is critical that roles and responsibilities for the effective planning, implementation, monitoring and revision of the closure process are clearly defined and provided for. The Holder of the Exploration Right is ultimately responsible for ensuring compliance with all the provisions of the Right and associated plans, as well as other relevant legal requirements. The Holder must ensure knowledge and understanding of the applicable legislation, guidelines, and industry best practices.

Capacity in the following key roles and responsibilities must be provided for:

- Internal Closure champion: a suitably qualified person(s) who will be accountable for the following:
    - Driving the ongoing development, refinement and implementation of the closure plan;
    - Resourcing and implementing the plan;
    - Ongoing management and monitoring requirements to support the closure plan;
    - To ensure the integration of the rehabilitation and closure activities with general operational activities; and

  - Ensure legal compliance and deliver on commitments.

- Internal Social champion: a suitably qualified person(s) who will be accountable for the following:
  - Develop and implement training strategies for internal training;
  - Develop and implement effective communication with all stakeholders;
  - Develop and implement a stakeholder forum to promote information and idea sharing regarding closure related aspects and/or ensuring meaningful contributions to existing forums; and
  - Continually develop the relationship with Interested and Affected Parties, to promote the social licence to operate and close and decommission.
- Independent Environmental Assessment Practitioner: This individual will be appointed to ensure compliance with the requirements of the final rehabilitation, decommissioning and closure plan and specifically to undertake the following tasks:
  - Undertake the required pre-closure environmental site assessment, risk assessment, and if required landowner consultations.
  - Prepare a site-specific final closure and decommissioning plan.
  - Undertake the required periodic compliance monitoring and reporting during the closure period.
- Well Engineer and or suitably qualified specialist/s: This individual must be a suitably qualified professional who must have relevant experience in petroleum exploration and production. Key attributes must include experience and qualifications related to the technologies applicable to production well closure and abandonment, as well as a thorough understanding of internationally accepted well closure and abandonment standard and guidelines. This specialist will be responsible for ensuring that the closure plan is implemented to ensure that the risks to the environment and surrounding communities are prevented or limited.

Further education, training and capacity building is critical to ensure that the production activities align with evolving internally accepted best practice and research. In this regard the Holder must ensure that regular review of international best practice is undertaken and where applicable implemented throughout the project programme. It needs to be recognised that closure planning needs to start early within the project lifecycle and continued as an integral component of the operations.

9.4 Identification of closure plan shortcomings

The gaps applicable to this closure plan are as follows:

- The specific locations of the exploration wells and associated infrastructure is unknown. These can only be defined once successful drilling has been undertaken. Consequently, the scope and content of the closure plan is largely dependent on the specific environmental context associated with the activities. The closure liability estimate will need to be updated (and where necessary the closure plan amended) once the exact locations are formally determined; and
- The exact geological stratigraphy and nature of the well profiles is unknown. The specific geological stratigraphy will be a determining factor in both the well designs and the planning for closure and decommissioning.

The following actions have been proposed to address these gaps:

- Complete the further exploration to determine the exact locations of the proposed new wells.
- A detailed drilling log will be prepared and maintained for each of the wells to ensure that the specific geological stratigraphy and sub-surface conditions are considered and inform the final site-specific closure and decommissioning plan;
- Annual updates to the hydrogeological model must continue; and
- Ensure continual review and assessment of the closure and decommissioning actions in relation the international best practice- considering ingoing research and development.

Further the financial provisioning regulations require that the final rehabilitation decommissioning and closure plan be revisited, assessed, and revised on an annual basis. This annual review must continue to aim to ensure that the gaps identified above are addressed, as applicable, and the relevant financial provisioning updated.

9.5 Relinquishment criteria

Relinquishment can be defined as the formal approval by the relevant regulating authority indicating that the completion criteria for the production activity have been met to the satisfaction of the authority. In this regard the relinquishment criteria are driven by the objectives of closure and consequently the indicators applicable to each impact associated with the closure and decommissioning. In summary the proposed relinquishment criteria include:

- Groundwater: the quality and quantity of the groundwater levels must be consistent with the pre-exploration condition- or adjusted depending on external inputs and drivers.
- Air quality: Evidence must be provided that there are no gas emissions from the well sites.

- Biodiversity: The vegetation cover of the affected areas must be consistent with surrounding vegetative cover. There must be ecosystem functionality which is consistent with the surroundings.
- Social: There must be no unattended complaints. Where possible written confirmation from the affected landowner must be solicited confirming that outstanding issues have been addressed and closed out.
- Waste: There must be no waste materials remaining on site.
- Land-use: The area must be available for ongoing land use consistent with the surroundings and as agreed with the land owner. The location of all exploration wells must be demarcated and where appropriate reflected on the relevant property title information.

9.6 Closure cost and financial provision for the final rehabilitation, decommissioning and closure plan

The closure cost estimation was determined in accordance with the requirements of GNR1147. The GNR1147 quantum is expected to represent a realistic estimation of the required cost for effective decommissioning, rehabilitation, closure, and management of ongoing residual, and potential future latent, impacts.

9.6.1 Approach to final closure cost determination

Funds must be available at any time, equal to the sum of the actual costs of implementing the plans and reports for a period of 10 years (as per Section 7, Chapter 2 of the Financial Provisioning Regulations, 2015).

The Financial Regulations specify an accuracy level of 70% for operations 30 years or less (but more than 10 years). The remainder of this section provides details on the proposed closure cost. The assumptions and limitations stated above, also underpin the basis of this closure cost determination.

The closure cost has been calculated through the following steps:

- Review of available information to inform the closure battery limits for the exploration;
- Verify unit rates for infrastructure dismantling and demolition as well as associated rehabilitation of disturbed areas, taking into account the latest demolition equipment available;
- Develop layout plans indicating existing and proposed infrastructure to be included in the rehabilitation and closure cost estimation;

- Unit rates were sourced from available precedents, inputs from specialists in the field, and experience;
- Rates are based on third-party contractor rates and not mining rates; and
- Apply the verified unit rates and associated quantities measured from the layout plans in spreadsheets to determine the closure costs.

The battery limits for this closure provision assessment are limited to the footprint of the exploration wells. It is understood no new access roads will require construction during the closure phase.

9.6.2 Cost assumptions and qualifications

Closure cost estimations were determined using the following general and site-specific assumptions and qualifications:

- General
    - Only decommissioning and rehabilitation costs equating to an outside contractor establishing on-site and conducting decommissioning and rehabilitation-related work. Based on the above, dedicated contractors would be commissioned to conduct the demolition and work over the well site. This would require establishment costs for the demolition and rehabilitation contractors and hence, the allowance of preliminary and general (P&Gs) in the cost estimate. Allowance has also been made for third party contractors and consultants to conduct post closure care and maintenance work, as well as compliance monitoring.
    - Costs pertaining to workforce management, re-training/re-skilling are outside the scope of this costing.
    - Concrete footings and bases would be demolished to a maximum of 1 000 mm below the final surface topography.
    - All infrastructure on the well sites will be completely dismantled, regardless of whether it is foreseen that certain components would be sold off/transferred to third parties post closure. Hence, no allowance was made for the beneficial re-use of any of the infrastructure. Until such agreements have been put in place, the assumption remains that total demolition would be required.
    - Movable assets will be removed from site for sale and/or re used by Rhino (or associated contractors, where applicable), and the cost associated with dismantling and transport of these items are not included in the cost determination.
    - Fixed ratios for P&Gs, contingencies and socio-economic mitigation measures have been applied.

- Income from the sale of salvage steel does not offset closure cost allowances.
- Closure costs have been determined for the scheduled and unscheduled closure scenario only. Scheduled closure takes place at a planned date and/or time horizon in accordance with overall exploration planning and unscheduled takes place should the exploration operations close with the infrastructure as is at present.
- The costs have been reported in present day costs. Closure cost estimations were determined using the following general and site-specific assumptions and qualifications:
- It is assumed that the management and mitigation measures suggested in the EIA Report relating to ongoing environmental management are complied with. This includes post-production clean-up and rehabilitation.

- Site specific
  - It was assumed that the ten exploration wells will be sealed off by pumping grout/cement into the well as part of the closure and rehabilitation phase. The pressure grouting/cementing of the wells will be undertaken from near the base of the well to surface, commonly known as the Halliburton Method. In addition, it is assumed that all drilling, including casing and grouting, is carried out in accordance with industry best practice and the applicable guidelines and that permeable zones are adequately isolated (including the usable ground water aquifers) as part of the well closure.
  - It is assumed that the loggers will provide a statement, based on the well bond log tests to be carried out, to inform the closure methodology of each well during the construction phase. In the event of unplanned closure, the latest statement will be used to inform the decommissioning plan.
  - General waste generated during the demolition and remediation phase will be disposed of at a general landfill site.
  - Hazardous waste generated during demolition will be disposed of at a registered hazardous landfill site.
  - A dedicated salvage yard and de-contamination bay will be established to de-contaminate demolition waste and screen recyclables.
  - No allowance was made for the rehabilitation of unsuccessful exploration wells. It was assumed that these wells will have been rehabilitated during operation.
  - No allowance was made for post closure water treatment after rehabilitation has been completed.

- Preliminaries and general: allowance of 10% of rehabilitation and closure action costs.
- Contingencies: Allowance of 10% of rehabilitation and closure action costs.

9.6.3 Description of unit rates

Unit rates that were applied during the closure determination were obtained from GCS's existing database. The database is updated in consultation with demolition practitioners and/or civil contractors. The post-closure unit rates that are included in the applied rates are summarised in the subsections below.

9.6.3.1 General surface rehabilitation

General surface shaping

It was assumed that general surface shaping would be required over 50 m^2 of the well sites where surface infrastructure has been removed, as part of the overall surface rehabilitation. This includes the stockpiling of building/demolition rubble to be removed for disposal, as well as the subsequent shaping and profiling of these surfaces. It has been assumed that shaping and profiling would involve the dozing of material at a 500 mm average thickness. With an adopted dozing rate of R 22/m^2, this equates to about R11 000.00/well.

Gravel Roads

No new gravel roads will be build for the implementation of or the closure of the exploration wells. As such, no provision has been made for the rehabilitation of any access roads.

Ripping

About compaction alleviation, allowance has been made for a mid-sized dozer equipped with 3 ripper tines, ripping to a depth of approximately 500 mm for compaction alleviation. An average unit rate of R5 862.86/ha was estimated based on a wet rate of R1 284.50/hr at a rate 60m^2/minute.

Vegetation

In terms of vegetation establishment, if vegetation must be established on uncompacted growth medium/topsoil, soil amelioration will most likely be required. This will depend on the nature of the soil. To determine a unit rate for re-vegetation, allowance has been made to apply 0.5 ton/ha fertiliser, 5 ton/ha lime and 15 ton/ha organic material such as well-cured cattle manure. If cultivation and seeding are also included, but ripping to alleviate compaction excluded, this rate equates to R60 161.84/ha.

Surface water monitoring

Allowance has been made to conduct the surface water monitoring at 2 monitoring points per well. If assumed that it would take at least one man-day of an independent specialist (including the preparation of the sampling equipment) to conduct the sampling at these points, this would equate to about R14 702.00 per sampling event for professional fees and associated disbursements. If an additional allowance is made for sample analysis of R1 300.00 per sample, this equates to an additional amount of R 3 900.00, totalling to R 17 600.00 per event. It has been assumed that surface water monitoring should continue 2 years' post-closure at a bi-annual frequency (R37 202.00/year).

Groundwater monitoring

It has been assumed that 10 groundwater monitoring boreholes would be required to reflect post closure groundwater quality. If it is assumed that two man-days would be required to conduct a monitoring event (including preparation, purging ex.) this would equate to about R 25 202.00 per sampling event for professional fees and associated disbursements. Allowance has also been made to conduct chemical sample analysis at R3 500.00/sample. Hence, these costs amount to about R 60 202.00 per event. It has been assumed that groundwater monitoring should continue for 2 years post-closure at an annual frequency. If not sign of contamination is picked up in the 2 years, the sampling can cease.

Rehabilitation monitoring

Biodiversity and soils (Landscape Function analysis) assessments (including mid-wet season) should be undertaken by a suitably qualified ecologist / botanist / soil scientist to monitor the rehabilitation progress. The monitoring should take place for bi-annually, 1 years after rehabilitation. There should be confirmation that acceptable cover has been achieved in areas where natural vegetation is being re-established. 'Acceptable cover' means re-establishment of pioneer grass communities over the disturbed areas at a density similar to the surrounding undisturbed areas, non-eroding and free of invasive alien plants.

It was assumed that one man-day would be required to conduct the rehabilitation monitoring over the disturbed area. Assuming a consultant rate of R600.00/hr, this would equate to R 9 000.00 per event for professional fees and associated disbursements. Hence, these costs amount to about R 9 101.00 per event. It has been assumed that rehabilitation monitoring should continue for 2 years post-closure at a bi-annual frequency (R18 202.00/year).

Rehabilitation care and maintenance

It is assumed that this would require 1 weeks per year of a team of 3 workers to conduct the corrective measures the total disturbed areas associated with the closure activities. It is assumed that the hourly rate of the workers is R 38/hr). Care and maintenance should continue for 2 years post-closure. The overall rate is R 4 560.00/year. It has been assumed that the workers and equipment could be sourced locally.

9.6.3.2 Site specific

Site specific unit rates were calculated based on experience and rates obtained from contractors. The site-specific unit rate is based on a per-well unit rate provided by a contractor, Torque Africa who provided a price for rehabilitation and decommissioning of R120 000.00 per exploration well.

The rehabilitation and decommissioning cost are based on the preliminary design provided in Figure 9-1.

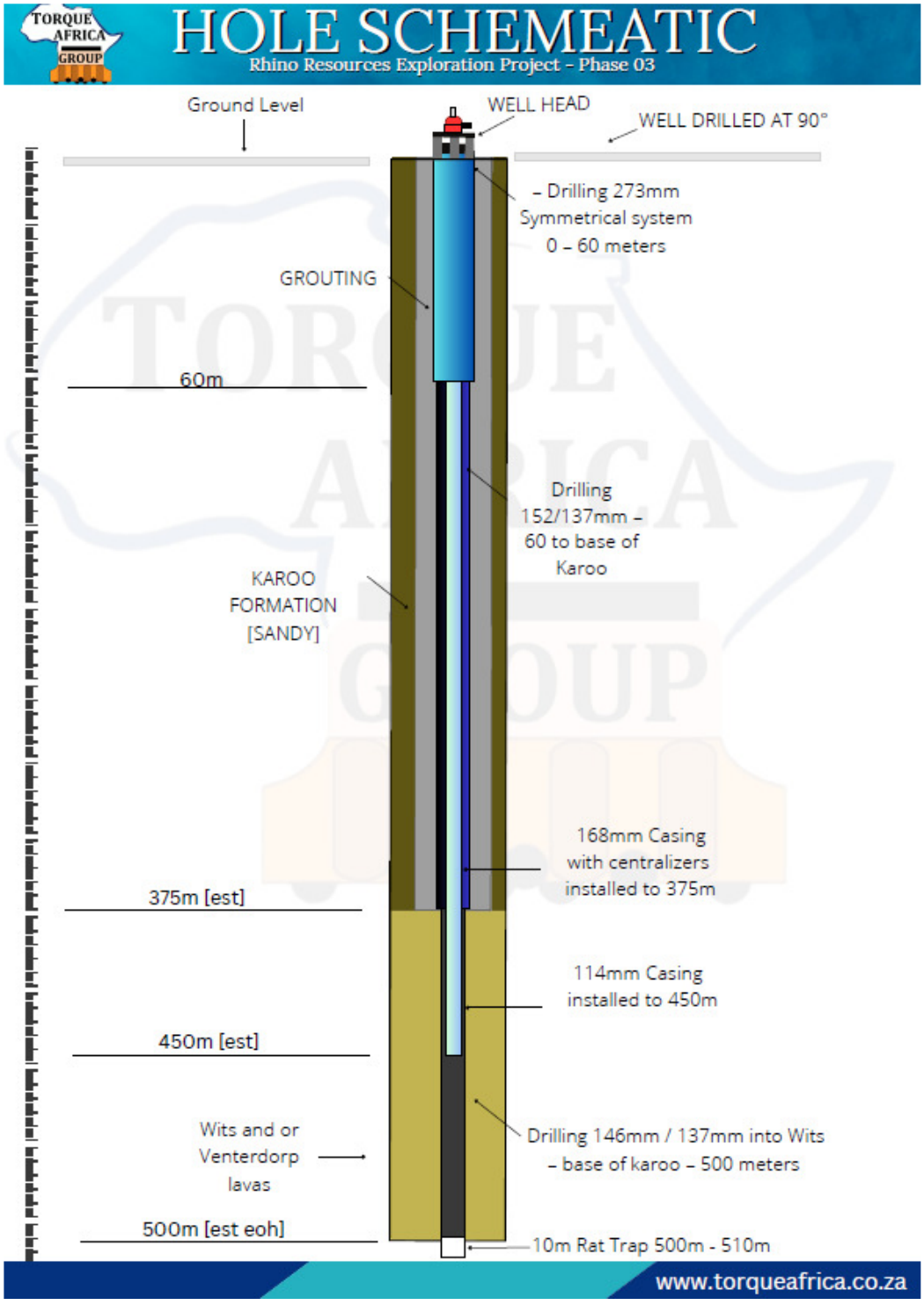

Figure 9-1: Hole schematic for exploration hole rehabilitation and decommissioning (Source: Torque Africa)

Down hole surveys

Allowance was made to survey the existing and proposed wells to determine the pre-decommissioning conditions (e.g. blockages to ensure the wells are plugged/rehabilitated to the ultimate depth).

Unit rate composition:

- Personnel – supervisor (1) 33 days @ R6 300.00/day;
- Personnel – skilled (2) 30 days @ R2 630.00/day;
- Survey equipment – wire line winch & dummies, generator, dip meters, hand tools, shovels & picks required for 21 wells total cost @ R7 570.00; and
- Survey 4x4 LDV allowance made for 4 500km @ R7.81.

Total cost for conducting pre-closure down hole survey per hole is R24 318.96.

Bond log testing

Allowance was made to test the integrity of the grouting in the wells to ensure there are no poor grouting bonds or inconsistent densities. All gas well locations will require CBL test work to be done prior to final closure. Based on the geographical location of each well, three wells can be tested per day at a daily cost of R9 140.00. Future associated costs include:

- Logging unit preparation and mobilization/demobilization, @ R7 646.00;
- Logging caliper/gamma ray sonde per m, @ R11.35;
- Logging CBL sonde per m, @ R23.90;
- Log processing, analysis and formal reporting per m, @ R39.29.

Total cost per well amounts to R58 782.47.

Unblocked collapsed wells

Allowance was made for the unblocking of collapsed wells to ensure isolation/sealing to depth. This is key in preventing future preferential pathways for potential groundwater contamination.

Unit rate composition:

- Drill, Compressor, Labour & Equipment per hole @ R158 641.00.

9.6.4 Final rehabilitation, decommissioning and closure cost estimate

The closure cost for the 10 exploration wells planned for the ER 318 area is estimated to be R8 786 424-66 (excluding VAT) at the end of the project life cycle. This is based on the assumption that exploration activities will commence in *circa* 2023 and the planned additional drilling to be undertaken in the forthcoming 12 months following construction commencing. This closure cost is based on 2022 values and will require annual reassessment, revision, and escalation. Table 9-3 provides a summary of the determined closure cost estimate.

Table 9-3: Scheduled and unscheduled closure liability assessment

Decommissioning and closure	Scheduled 2023	Unscheduled 2023 (cost per well)
Down hole surveys for wells	R 1 215 948.00	R 1 215 948.00
Un-block collapsed wells	R 793 205.00	R 793 205.00
Sealing of wells, capping and abandonment	R 600 000.00	R 600 000.00
General surface rehabilitation	R 88 150.91	R 88 150.91
Establishing vegetation	R 30 080.92	R 30 080.92
Rehabilitation monitoring	R 36 404.00	R 18 202.00
Rehabilitation care and maintenance	R 49 000.00	R 24 500.00
Closure phase monitoring	R 1 071 520.45	R 1 071 520.45
Preliminaries and General	R 341 903.14	R 34 190.32
Contingencies	R 284 919.28	R 28 491.93
Total final rehabilitation, decommissioning and closure cost (excluding VAT)	**R 4 547 535.70**	**R 3 904 289.53**

9.7 Monitoring, auditing and reporting

The requirement for monitoring and auditing should be carried through all phases of the project lifecycle. The financial provision regulations require that monitoring, auditing and reporting which relate to the risk assessment legal requirements and knowledge gaps as a minimum and must include-

i. a schedule outlining internal, external, and legislated audits of the plan for the year, including

   a) the person responsible for undertaking the audit(s);

   b) the planned date of audit and frequency of audit;

   c) an explanation of the approach that will be taken to address and close out audit results and schedule;

ii. a schedule of reporting requirements providing an outline of internal and external reporting, including disclosure of updates of the plan to stakeholders;

iii. a monitoring plan which outlines

a) parameters to be monitored, frequency of monitoring and period of monitoring; and

b) an explanation of the approach that will be taken to analyse monitoring results and how these results will be used to inform adaptive or corrective management and/or risk reduction activities.

This section aims to present the monitoring plan which will need to be implemented in the rehabilitation and decommissioning, and closure phases. For detail on the monitoring requirements during the production and progressive rehabilitation phase, and the post-closure phase, please refer to the appropriate sections above.

For the purposes of this closure plan the monitoring and auditing is separated into two distinct categories namely, compliance monitoring and environmental monitoring. The compliance monitoring will typically align with, and be a continuation of, the requirements of compliance monitoring and reporting as specified in the EMPR. Table 9-4 and Table 9-5 provide the compliance monitoring and reporting plan and the environmental monitoring and reporting plan respectively, applicable to the decommissioning, rehabilitation, and closure phase.

In accordance with Regulation 11 of the National Environmental Management Act (Act No. 107 of 1998): Financial Provisioning Regulations (2015) the Holder must ensure annual review of the annual rehabilitation plan, the final rehabilitation decommissioning and closure plan, as well as the environmental risk assessment. This annual review must be audited by an independent auditor.

All monitoring and auditing must be accompanied by applicable records and evidence (e.g. delivery slips, photographic records, etc). All reports must be retained and made available for inspection by the ECO, the Holder and /or the Relevant Competent Authorities. Copies of all documentation, permits, licences, and authorisations (incl. copy of EA and relevant amendments to the EMPR and EA, waste disposal certificates, disposal licences, water use licences, etc.) must be obtained and kept in a site environmental file.

An environmental compliance register must be prepared and maintained throughout construction, operation and decommissioning in order to monitor environmental concerns, incidents, and non-conformances. This register should be utilised to measure overall environmental performance.

The applicant must use the audit report findings to continually ensure that environmental protection measures are working effectively on site through a system of self-checking. The EMPR should be viewed as a dynamic document aimed at continual environmental performance improvement. In this regard the provisions of Regulation 34-37 of GNR 982 apply to the process of amending the EMPR.

Table 9-4: Compliance monitoring and reporting plan

Type	Functional requirement	Responsibility	Frequency	Reporting mechanism
Daily site inspections	• Undertake site inspections. • Photographic record of site activities. • Data capturing for record and compliance verification purposes. • Daily site inspection diary.	Environmental Officer (EO)	Daily	No routine reporting. *Ad hoc* as necessary.
Monthly Compliance Report	• Monitor and report on compliance with the requirements of the EA, EMPr, and closure plan and general environmental performance. • Include the results of all relevant environmental monitoring. • Include status of rehabilitation activities. • Include records of: o Waste manifests. o Incident registers. o Complaints registers. o Relevant corrective action reports.	Environmental Officer (EO)	Monthly	Monthly compliance report
Monthly ECO Audits (Decommissioning Phase)	• Site inspection and photographic record. • Audit and report on compliance with EA, EMPR and final rehabilitation, decommissioning and closure plan. • Monitoring compliance with Annual rehabilitation Plan. • Alignment with requirements of Appendix 7 of GNR982 (as amended), National Environmental Management Act (Act No. 107 of 1998).	Independent ECO/Environmental Auditor	Monthly	Monthly Audit Report
Annual Independent Audit	• Site inspection and photographic record.	Independent ECO/Environmental Auditor	Annual	Annual Environmental Compliance Audit Report

Type	Functional requirement	Responsibility	Frequency	Reporting mechanism
	• Audit and report on compliance with Environmental Authorisation, EMPR and final rehabilitation, decommissioning and closure plan. • Monitoring compliance with Annual rehabilitation Plan • Alignment with requirements of Appendix 7 of GNR982 (as amended), National Environmental Management Act (Act No. 107 of 1998).			
Annual review of financial provisioning reports in accordance with the requirements of Regulation 11 of the Financial Provision Regulations.	• Review, assess and adjust: o Annual Rehabilitation Plan; o Final rehabilitation, decommissioning and closure plan; and o Environmental Risk Assessment. • Ensure on-going compliance with the requirements of the Annual Rehabilitation Plan and the final rehabilitation, decommissioning and closure plan.	Independent specialist	Annual	Annual Financial Provision Assessment and update.

Table 9-5: Monitoring plan

Aspect	Applicable phase	Functional requirement	Performance indicator / target	Frequency	Reporting mechanism
Surface water	• Decommissioning • Closure • Post-closure (5 years post closure)	Standards: o Aquatic Water Quality Standards as published in the Department of Environmental Affairs (DEA) (2014): Framework for the Management of Contaminated Land;	• Target: < 10% variation in upstream and downstream if exceeded then review and institute additional monitoring and investigation.	• Bi-annual when active construction/ decommissioning activities within applicable catchment for a duration of 2 years post closure.	✓ Monitoring report. ✓ Annual Environmental Audit Reports

Aspect	Applicable phase	Functional requirement	Performance indicator / target	Frequency	Reporting mechanism
		○ South African National Standards (SANS) 241 1:2011 drinking water standards (SABS, 2015) which sets numerical limits for specific determinants to provide the minimum assurance necessary that the drinking water is deemed to present an acceptable health risk for lifetime consumption. Locations: Watercourses within 500m radius of any proposed well locations. Parameters: Full monitoring set			
Groundwater	• Decommissioning • Closure • Post-closure (2 years post closure)	Standards: as per the prevailing routine monitoring requirements or alternatively: ○ Guidance on Sampling Techniques (SABS ISO 5667:2:1991), Guidance on Sampling of Groundwater (SABS ISO 5667:11:2009) and Guidance on the Preservation and Handling of Samples (SABS ISO 566 7:3:1994). Laboratory analysis undertaken at a SANAS. Accredited Laboratory.	• Alignment with background and baseline values. • An increase in any of the indicator elements by more than 25% from baseline conditions will trigger a response from Rhino. • The lowering in groundwater level by more than 10m will trigger a response from Rhino.	• Decommissioning and Closure: Bi-monthly as per the production/operational phase monitoring requirements. • Post-closure: Annually	✓ Annual Monitoring Report. ✓ Annual Environmental Audit Reports

Aspect	Applicable phase	Functional requirement	Performance indicator / target	Frequency	Reporting mechanism
		Locations: Monitoring points provided by the groundwater specialist, assumed to be one at every well location as a minimum. Monitoring parameters (minimum): • Full monitoring set. • Physical parameters: Groundwater levels.	• No water supply (quality and quantity) complaints.		
Biodiversity	• Decommissioning • Rehabilitation • Closure	Standards: ○ Conservation of Agricultural Resources Act, Act No. 43 of 1983 ; National Environmental Management: Biodiversity Act, Act No. 10 of 2004 alien and invasive species list (2014). ○ Timed random meander method. Parameters:	• Target: Confirmation that acceptable cover has been achieved in areas where natural vegetation is being re-established. "Acceptable cover" means reestablishment of pioneer grass communities over the disturbed areas at a density similar to surrounding undisturbed areas, non-eroding and free of invasive alien plants.	• Biodiversity assessments mid wet season should be undertaken by a qualified ecologist / botanist to monitor the rehabilitation progress. Bi-annual survey for a period of 1 years after rehabilitation.	✓ Annual Monitoring Report. ✓ Annual Environmental Audit Reports

Aspect	Applicable phase	Functional requirement	Performance indicator / target	Frequency	Reporting mechanism
		○ Flora and Fauna Surveys: Plant community composition. Alien and invasive plant abundance (numbers, density, cover, frequency); Condition measures of vigour, performance, fecundity); Structure size or age class information). Locations: All exploration well areas and adjacent area (radius of 20m). Random meanders within all defined rehabilitated natural areas.	• Indicators: New species appearing on site, alien species list (including density information), change in composition/ structure of native plant communities, extent of invasive species populations, record of clearing activities, decline in abundance of alien plant species over time.		
Wells	• Decommissioning • Rehabilitation • Closure • Post-closure	Standards: ○ Plug / barrier evaluation and verification: Well plugging and abandonment verification to confirm that there is proper and effective vertical isolation (this could include: bond log tests, cementing tests, communication tests, hydraulic pressure tests, applied weight test). This should be informed by a well engineer and the applicable API standards.	• Pass barrier evaluation and verification test. • No stray gas or fluid migration. • VOCs GLCs should comply with the TCEQ guideline. • Soil gas measurements should not exceed relevant reference site values. No temporal increase in the soil gas.	• Plug evaluation / verification: Once off post plugging. • Soil and surface gas levels monitoring annually for a period of 2 years post closure.	✓ Annual Monitoring Report. ✓ Annual Environmental Audit Reports

Aspect	Applicable phase	Functional requirement	Performance indicator / target	Frequency	Reporting mechanism
		○ Gas emissions: Passive diffusive sampling, National Ambient Air Quality Standards (GN1210/20 09). The well site must be monitored for the release of gas from the decommissioned well site. This may be done by soil vapour testing or effluxes and/or surface methanometer or alternative method approved by a qualified well Engineer or Independent Environmental Specialist. Locations: At all closed / abandoned wells.			

10 ANNUAL REHABILITATION PLAN

The annual rehabilitation plan aims to:

- Review concurrent rehabilitation and remediation activities already implemented;
- Establish rehabilitation and remediation goals and outcomes for the forthcoming 12 months, which contribute to the gradual achievement of the post-production land use, closure vision and objectives identified in the holder's final rehabilitation, decommissioning,;
- Establish a plan, schedule, and budget for rehabilitation for the forthcoming 12 months;
- Identify and address shortcomings experienced in the preceding 12 months of rehabilitation; and
- Evaluate and update the cost of rehabilitation for the 12-month period and for closure, for purposes of supplementing the financial provision guarantee or other financial provision instrument.

The purpose of an Annual Rehabilitation Plan report is to provide a record containing the relevant information regarding concurrent rehabilitation and remediation activities for the site for the forthcoming 12 months and how these relate to the operation's closure vision, as detailed in the final rehabilitation, decommissioning and closure plan. The Annual Rehabilitation Plan also indicates what closure objectives and criteria are being achieved through the implementation of the plan.

10.1 Shortcoming identified during the preceding monitoring period

This report is limited to the proposed gas exploration wells, the project which has yet to commence and therefore no shortcomings during the preceding period are relevant.

10.2 Planned rehabilitation and remediation

Planned rehabilitation is divided into two main categories, namely: Addressing accumulated rehabilitation backlog or identified shortcomings from previous periods; and progressive rehabilitation associated with ongoing operations. Similar to the shortcomings described in Section 10.1, the proposed exploration activities have not yet commenced and therefore no planned rehabilitation and remediation measures are relevant at this time.

11 ANNUAL REHABILITATION COSTING

According to the Financial Provisioning Regulations (2015) the objective of the environmental risk assessment report that relates to latent and residual impacts is to:

- ensure timeous risk reduction through appropriate interventions;
- identify and quantify the potential latent environmental risks related to post closure;
- detail the approach to managing the risks;
- quantify the potential liabilities associated with the management of the risks; and
- outline monitoring, auditing, and reporting requirements.

This section of the report aims to address these objectives separately. In certain cases, these objectives have been discussed and presented in the preceding sections of this report.

11.1 The assessment process used and description of latent environment risk

Preceding sections of this report provides a detailed description of the environmental impact/risk identification and assessment (including the methodology and findings) undertaken. These sections also includes identified mitigation measures which, once implemented successfully, will result in the avoidance or acceptable reduction of the associated impact. The primary latent and residual risks identified to potentially occur are listed below:

- Well casing and/or cementation failure affecting groundwater quality as a result of vertical migration of fluid and/or gas.

The measures considered to ensure that the risk of vertical zonal interaction (groundwater interplay between aquifers, and/or hydrocarbon movements) is mitigated, is the plugging of the entire well, as previously required under Regulation 132 of the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002) Regulations and industry best practice. In order to ensure that the closure vision, objectives and targets are met, the possibility that the integrity of the well plug may deteriorate over very long periods of time has been considered in the Environmental Risk Assessment prepared for this report.

The drivers that could result in the manifestation of the latent risk are largely defined by the specifics of the site location and the geological profile surrounding each specific well. Table 11-1, presents the identified latent and residual risks; the assessment of the impacts; the recommended management and mitigation measures; the impact drivers, timeframes, and triggers; as well as the suggested closure options and actions.

Table 11-1: Latent and residual risks

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Prost-mitigation risk (post-mitigation)	Impact drivers	Impact timeframes	Impact triggers	Closure options/action
Groundwater	Well casing and/or cementation failure affecting groundwater quality as a result of vertical migration of fluid and/or gas.	-16 (medium)	Well abandonment and plugging to comply with the requirements of the Petroleum Regulations and accepted best practice. Rhino will implement well-specific plugging requirements protect the shallow potable Karoo aquifers at closure. Well design will be done by a qualified well engineer or other suitably qualified specialist/s who will take corrosion, pressures, temperatures, exposure times, production life and well rehabilitation into consideration. The cement seals will be pumped as a water cement slurry down the casing to the bottom of the well, leaving a sheath of cement to set and harden. The integrity of the seals should, where applicable, be pressure	-9 (medium)	• Geological profile of closed well bore. • Well casing integrity. • Suitability and quality of the annulus barrier. • Suitability and quality of final well bore plug (mechanical factors as well as plug material factors). • Nature of the intersected flow (gas/ water) zones.	Unknown. Depending in the nature of the well and formations the impact may occur at any time in the future.	Elevations in dissolved gas and deep aquifer indicators in shallow groundwater. Gas emissions on surface.	Well closure and abandonment according to the rehabilitation, decommissioning final closure plan and applicable international best practice.

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Prost-mitigation risk (post-mitigation)	Impact drivers	Impact timeframes	Impact triggers	Closure options/action
			tested before the next phase of drilling commences. If the well fails the pressure test, the casing will be recemented before drilling continues. Testing will be implemented to ensure that the plug is placed at the proper level and provides adequate protection of permeable zones, for example the fracture zones from which gas was produced and the overlying Karoo aquifers. These tests should include tagging the top of the plug. Pressure testing should be undertaken on the seal but care should be taken not to damage the seal during pressure testing.					

Aspect	Impact	Pre-mitigation risk	Suggested mitigation measures	Prost-mitigation risk (post-mitigation)	Impact drivers	Impact timeframes	Impact triggers	Closure options/action
			Swabbing can be undertaken to remove fluids from the well. Upon completion of the rehabilitation of the well, a surface casing vent flow test should be considered to determine whether gas or liquid or a combination thereof is escaping from the casing. If gas is detected during this test, additional seals should be designed and implemented. A groundwater and gas monitoring programme will be implemented at each well to serve as an early detection mechanism. Rhino has also prepared a Gas Well, Closure, Abandonment and Rehabilitation Guideline document which will be complied with.					

12 MANAGEMENT ACTIVITIES, COSTING AND MONITORING REQUIREMENTS

Prevention through accuracy of implementation is the key to addressing and reducing possible latent and residual impacts. This section aims to define the actions required during the post closure phase to manage, address, and monitor residual and latent risks.

12.1 Monitoring requirements and corrective management

The section of this report that deals with the risk assessment aspects, provides a breakdown of the monitoring and auditing requirements for the operation, rehabilitation and decommissioning, closure, as well as post-closure phases. The post closure phase monitoring will aim primarily to monitor key drivers and parameters which causally relate to the predicted latent and residual impacts, and where applicable to trigger management and mitigation activities associated with these. The specific monitoring aspects identified include the following (refer to Table 9-5 for more detail):

- Surface water monitoring: 2 years post closure; (bi-annually)
- Groundwater monitoring: 2 years post closure (bi-annually); and
- Surface gas: 2 years post closure (annually).

Testing of grouting and barriers will be essential for this project and should be implemented for each well, immediately after grouting. Effective records of the drilling results, cement used, and testing results must be kept for the life of each well. A final test should be carried out during the closure phase and is to be informed by a qualified well engineer. The results and the life of well records must be made available to the well engineer, to inform the plug design.

12.2 Management and mitigation measures

The monitoring plan described above will provide invaluable insight into the likelihood that the risk will materialise and the expected timeframes and durations of the impacts. On the basis of the current risk assessment and predictive methods, it is expected that certain post closure management activities and mitigation measures will be required. Table 12-1 presents the impacts and associated mitigation measures identified once the impact is manifest. The alternatives considered and the motivation for the proposed alternatives are also presented. Please refer to earlier sections of this report for a more detailed explanation of each alternative and the associated advantages and disadvantages.

Table 12-1: Post closure management activities and mitigation measures.

Impact	Alternative	Selected alternative
Well casing and/or cementation failure affecting groundwater quality because of vertical migration of fluid and/or gas.	Identify the specific sources of the fluid /or gas and remove pathway. This could include redrilling and plugging affected well sites.	Rhino should make provision for re-plugging/topping up a reasonable percentage of wells.
	Identify affected receptors and provide alternative resources (e.g. alternative water supply options).	
	Interception of contaminated water, treatment and discharge.	
	Restrict future development on affected high risk areas.	

12.3 Costing estimation for residual and latent impacts

The monitoring plan described above will provide invaluable insight into the likelihood that the risk will materialise and the expected timeframes and durations of the impacts. However, it is considered prudent that some form of financial provision is made for well integrity failure post closure at this early stage.

Patroni (2007) completed a study on the lifespan of wells-based corrosion and casing thickness and found that the lifespan of the casing tested is 75 – 110 years. In addition, the hydrogeological specialist study compiled as part of the EIA considers the post-mitigation risk as relatively low. Furthermore, various studies carried out in Pennsylvania, USA between 2008 and 2013 have found gas well failures resulting in gas leaks to be as low as 2,5% to 3,4% (Vidic et al, 2013).

Based on this variable information the following is proposed:

Surface Methane Monitoring: The surface methane gas monitoring period is to be increased to 5 years at a frequency of once per year for each well. It has been assumed that 10 locations will require monitoring post closure for a period of 5 years. This can be undertaken through appropriate sampling techniques, either soil vapour probes, effluxes, or surface methanometers. If it is assumed that 5 man-days would be required to conduct a monitoring event (including preparation, site establishment, equipment hire ect.) this would equate to R113 270.32 per event.

- Re-drilling and Re-plugging of Wells: An allowance to re-drill and cement three of the wells during the 5 year period has been proposed. The following costs are associated with this activity:
    - Excavation of material to access plug, @ R13 061.14
    - Removal of plug and re-drill, @ R247 190.25

- Plug of well, @ R260 965.60
- Surface Capping of Well, @ R8 022.29
- Backfill excavated area, @ R528.51

Therefore, the total cost to re-drill/plug one well amounts to R529 767.81.

- Groundwater Monitoring: It is suggested that groundwater monitoring at each well site should continue for 2 years post closure. Monitoring is to be performed once per year during April, the month when aquifers are at their fullest. If it is assumed that two man-days would be required to conduct a monitoring event (including preparation, purging ect.) this would equate to about R 25 202.00 per sampling event for professional fees and associated disbursements. Allowance has also been made to conduct chemical sample analysis at R 3500/sample. Hence, these costs amount to about R60 202.00 per event.

A summary of the determined costs for the management of the identified residual and latent impact are provided in Table 12-2.

Table 12-2: Latent and residual cost estimation

Post-closure phase	Scheduled 2023	Unscheduled 2023 (for one well)
Surface water Monitoring	R 74 404.00	R 37 202.00
Ground water Monitoring	R 240 808.00	R 60 206.00
Gas leakage Monitoring	R 226 540.64	R 113 270.32
Latent and residual risk provision (redrill and plugging of wells)	R 529 767.81	R 529 767.81
Total latent and residual cost (excl. VAT)	**R 1 071 520.45**	**R 740 448.13**

The site-specific environmental assessments performed once the exact drill sites are known, as well as geological data gathered during the drilling process, will allow for a more detailed understanding of the risks related to this specific impact. This information, along with new international best practice guidelines that may be developed in the future, will be considered in all annual updates of the financial provisions and changes to the risk assessment will be reported on. In addition, monitoring results and auditing reports, as described in this report, for up to 10 years after decommissioning will inform the revised risk assessment further.

APPENDIX A

FINANCIAL PROVISION CALCULATION

Quantum Calculation for Financial Provision for Rehabilitation and Mine Closure							
Mine: Rhino Oil and Gas (Pty) Ltd				**Location:** Free State Province			
Evaluator: M van Rooyen from GCS (Pty) Ltd				**Date:** 10 April 2023			
No.	**Description**	**Unit**	**A: Quantity**	**B: Master Rate (rands)**	**C: Multiplication factor**	**D: Weighting factor 1 E=AxBxCxD**	**Amount (rands)**
			Step 4.5	**Step 4.3**	**Step 4.3**		
1	Down hole surveys for wells	/well/m	50.00	24 318.96	1.00	1.0	1 215 948.00
2	Un-block collapsed wells	well	5.00	158 641.00	1.00	1.0	793 205.00
3	Sealing of wells, capping and abandonment	No	5.00	120 000.00	1.00	1.0	600 000.00
4	General surface rehabilitation	ha	0.50	176 301.82	1.00	1.0	88 150.91
5	Establishing vegetation	ha	0.50	60 161.84	1.00	1.0	30 080.92
6	Closure phase monitoring	annually	2.00	18 202.00	1.00	1.0	36 404.00
7	Rehabilitation monitoring	annually	2.00	18 202.00	1.00	1.0	36 404.00
8	Rehabilitation care and maintenance	annually	2.00	24 500.00	1.00	1.0	49 000.00
	Subtotal 1						**2 849 192.83**
9	Preliminaries and general	**Ad 12% of Subtotal 1 if subtotal 1 < R 100 000 000.00**					341 903.14
10	Contingencies	**Ad 10% of Subtotal 1**					284 919.28
	Subtotal 2						**3 476 015.25**
11	Post closure monitoring - surface water	annually	2.00	37 202.00	1.00	1.0	74 404.00
12	Annual groundwater quality monitoring (post-closure)	bi-annually	4.00	60 202.00	1.00	1.0	240 808.00
13	Gas leakage monitoring	/5yr	2.00	113 270.32	1.00	1.0	226 540.64
14	Latent and residual risk provision (redrill and plugging of borehole)	sum	1.00	529 767.81	1.00	1.0	529 767.81
Subtotal 3 - Sum of Items 1 to 14							**4 547 535.70**
Multiply sum of 1 to 14 by Weighting Factor 2 (weighting factor 2 = 1.00)							**4 547 535.70**
VAT @15%							682 130.36
Grand Total (Subtotal 3 plust VAT)							**5 229 666.06**