2014

PROPOSED DEVELOPMENT OF THE OKANJANDE GRAPHITE MINE AND EXPLORATION ACTIVITIES

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

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PROJECT NAME	Environmental Impact Assessment for the proposed Okanjande graphite mine and exploration activities.
STAGE OF REPORT	Environmental Impact Assessment (EIA) Report – Final
CLIENT	Gecko Graphite Enquiries: Oliver Krappmann Tel: (061) 305 444 E-Mail: oliver@gecko.na
LEAD CONSULTANT	Enviro Dynamics Enquiries: Eloise Carstens Tel: (061) 223 336 E-Mail: eloise@envirod.com
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CONTRIBUTORS TO THE REPORT	Eloise Carstens, Carla Saayman, Eddy Kuliwoye Reviewer: Norman van Zyl

DECLARATION

I hereby declare that I do:

(a) have knowledge of and experience in conducting assessments, including knowledge of the Act, these regulations and guidelines that have relevance to the proposed activity;

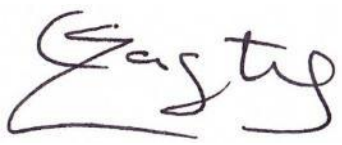
(b) perform the work relating to the application in an objective manner, even if this results in views and findings that are not favorable to the applicant;

(c) comply with the Act, these regulations, guidelines and other applicable laws.

I also declare that there is, to my knowledge, no information in my possession that reasonably has or may have the potential of influencing –

(i) any decision to be taken with respect to the application in terms of the Act and the regulations; or

(ii) the objectivity of this report, plan or document prepared in terms of the Act and these regulations.



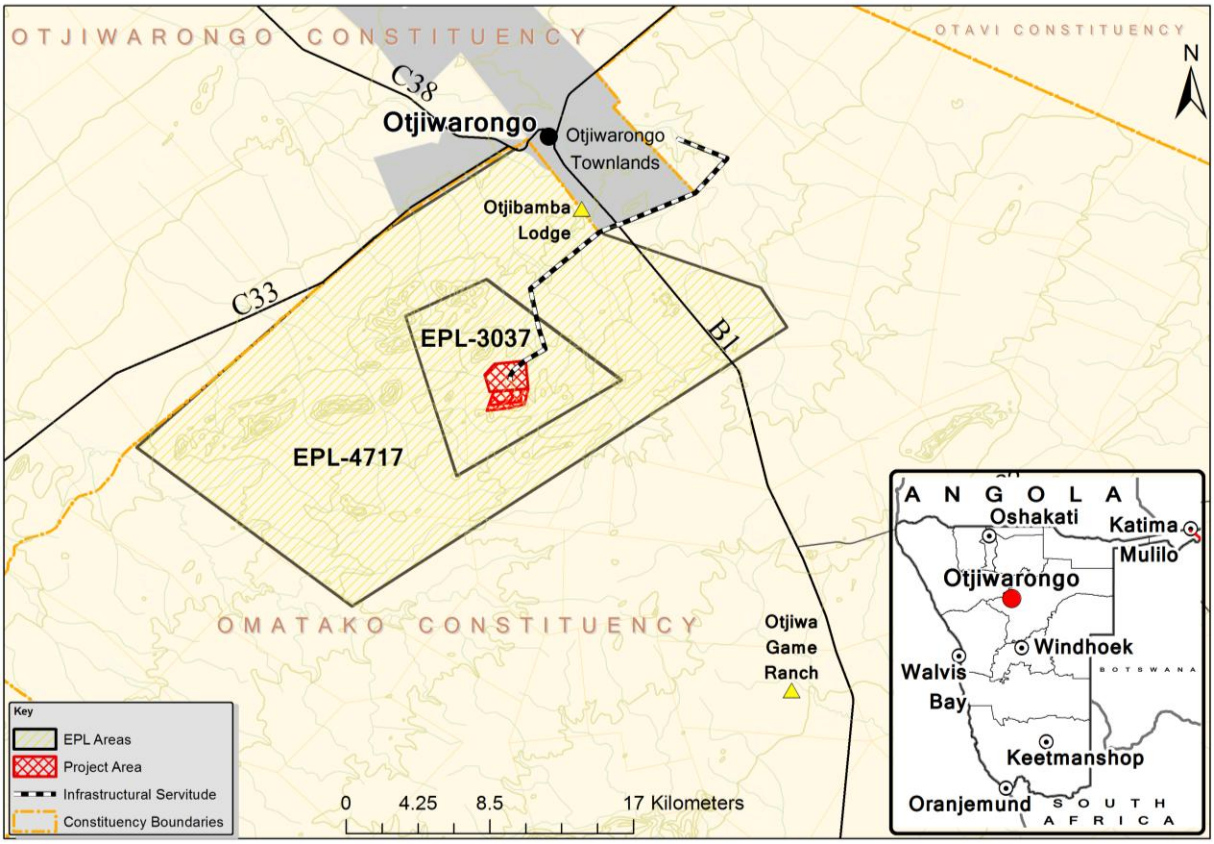
Eloise Carstens

Environmental Assessment Practitioner (EAP)

Executive Summary

Introduction

The Okajande graphite deposit is situated approximately 14 km south of Otjiwarongo in the Otjozondjupa region (see Figure 1-1). The reserve comprises an ore body extending to a depth of at least 70 m and has been determined to contain 34 million tons of graphite, occurring in flake form with an average carbon content of 5.14%.



Graphite is regarded as an essential and strategic commodity due to its key industrial applications in a very specialized market. Because of the present market price and increasing demand of graphite, Gecko Graphite, a Namibian-owned and operated company, proposes to develop a graphite mine and processing operations at the site. By doing so, they envisage securing a position in the market as a reliable supplier of high quality natural flake and powder graphite over a wide range of products. The target markets of these products are South Africa, America and Europe.

Gecko has appointed Enviro Dynamics to conduct an EIA that will be submitted in order for the project to obtain an Environmental Clearance Certificate from the Ministry of Environment and Tourism (MET).

Project Description

The proposed mine will be an open pit comprising 5 m benches to a depth of 85 m. Graphite production is expected to start at 5 000 tpa and increased to 20 000 tpa within five years. Run of mine (ROM) will be transported to a ROM stockpile, from which it will be fed to the processing plant with a front end loader. Waste rock will be transported to a small waste rock dump. A processing plant comprising of crushing, milling, heavy mineral separation, flotation, filtration, drying, screening and bagging will be constructed north of the pit area. Two alternatives for tailings disposal are being considered, namely a wet disposal method, whereby wet tailings slurry is pumped to the tailings storage facility (TSF) where it is dewatered, and a dry disposal facility whereby tailings slurry is dewatered at the plant site and transport with 30 tonne haul trucks to the TSF.

The Affected Environment

The Otjiwarongo area is characterized by a relatively flat plain with inselbergs, sandstone plateaux and low ridges standing out above the general land surface. Two main lithological units underlie the project area namely: the Nosib Group and Swakop Group (of the Damara Supergroup). The Nosib Group lithologies is made up of quartzite and hosts the graphite ore body which contains variable amounts of sulphide minerals that could lead to possible environmental impact through Acid Mine Drainage. The Swakop Group consists of marble and calcsilicate rocks. The Nosib Group rocks create at the project site a natural surface water divide causing the surface ephemeral channels to flow off from these lithologies in all directions. Groundwater flow directions are closely related to surface water drainage directions. From the mine site groundwater flows towards the northwest and then follows the surface drainage towards the northeast and southwest. Although the groundwater potential of the area is poor it is of local importance in the absence of other supply sources for farm residents and livestock farming.

The project area forms part of the thornbush savanna and is densely encroached by Acacia mellifera and Dichrostachys cinerea growing on fairly thin soil with occasional patches of bedrock exposed at the surface. The habitat of the mine site is widespread and homogeneous through central Namibia, and contains no unique or singular features of high ecological importance.

The economic activities of the Otjozodjupa Region are dominated by agriculture, tourism and mining. In terms of service provision, the Municipality of Otjiwarongo is currently faced with a large shortcoming, especially in terms of residential erven for the low and middle income residents.

Impact Assessment

The following table provides a summary of the significance of the impacts, as concluded by the specialists. The significance rating can be reduced through the implementation of the specific mitigation measures that are prescribed in the EMP.

SPECIALIST FIELD	POTENTIAL IMPACT	SIGNIFICANCE: PRE-MITIGATION	SIGNIFICANCE: POST MITIGATION
AIR QUALITY	**CONSTRUCTION PHASE**		
	PM2.5 Human health and animal Impacts	Low	Very Low
	PM10 Human health and animal Impacts	Medium	Low
	SO2 Human health and animal impacts	Low	Very Low
	NO2 Human health and animal impacts	Low	Very Low
	CO Human health and animal impacts	Low	Very Low
	VOC Human health and animal impacts	Low	Very Low
	Dustfall nuisance impacts	Medium	Low
	Dustfall impacts on animals	Medium	Low
	OPERATIONAL PHASE – DRY AND WET TAILINGS		
	PM2.5 Human health and animal Impacts	Medium	Low
	PM10 Human health and animal Impacts	Medium	Low
	Dustfall nuisance impacts	Low	Very Low
	Dustfall impacts on animals	Low	Very Low

SPECIALIST FIELD	POTENTIAL IMPACT	SIGNIFICANCE: PRE-MITIGATION	SIGNIFICANCE: POST MITIGATION
	DECOMMISSIONING PHASE		
	PM2.5 Human health and animal Impacts	Low	Very Low
	PM10 Human health and animal Impacts	Low	Very Low
	Dustfall nuisance impacts	Low	Very Low
	Dustfall impacts on animals	Low	Very Low
GROUND AND SURFACE WATER HYDROLOGY	**OPERATIONAL PHASE**		
	Seepage from TSF	High	Low
	Structural integrity of the TSF	High	Low
	Position of TSF	High	Low
	Perimeter trench	High	Low
	ROM stockpile	Medium	Low
	Waste rock stockpile	High	Low
	Waste water	Medium	Low
	Local water supply	Low	Low
	DECOMMISSIONING PHASE		
	Contamination and risk after closure from mine pit	Medium	Low
	Contamination after closure of TSF	Medium	Low

SPECIALIST FIELD	POTENTIAL IMPACT	SIGNIFICANCE: PRE-MITIGATION	SIGNIFICANCE: POST MITIGATION
	tailings storage facility stability	Medium	Low
	waste rock stockpile	Medium	Low
FAUNA AND FLORA	**CONSTRUCTION PHASE**		
	Clearing of land, particularly of tall trees	Medium	Medium – Low
	Collisions against power lines	Low	Low
	Large birds drowning in water reservoirs	Medium	Low or impact removed altogether
	Increased human presence, resulting in illegal hunting	Low	Unlikely to remove the problem altogether. Impact stays Low.
	OPERATIONAL PHASE		
	Migration of animals -aboveground pipeline	Low	Low
	Birds nesting on power line towers	Low	Low
	Collisions against power lines	Low	Low
	Drownings in reservoirs	Medium	Low or impact removed altogether
	Illegal hunting	Low	Unlikely to remove the problem altogether. Impact stays Low.
ARCHAEOLOGY	**ALL PROJECT PHASES**		
	Impact on local archaeology and historically significant sites	Low	Low

SPECIALIST FIELD	POTENTIAL IMPACT	SIGNIFICANCE: PRE-MITIGATION	SIGNIFICANCE: POST MITIGATION
SOCIO-ECONOMIC ENVIRONMENT	**CONSTRUCTION PHASE**		
	Contribution to the Namibian economy through capital expenditure	Low	Medium (positive)
	Secondary Economic Boost	Low	Low to Medium (positive)
	Job creation (if foreign)	Medium	Low
	Job creation	Low	Medium (positive)
	Pressures on available services and housing for on-site housing	High	Medium to Low
	Pressures on available services and housing for off-site housing (Otjiwarongo)	Medium	Medium to Low
	Increased traffic along routes between SA and Namibia, and Walvis Bay and the site	Low	Very Low
	Change to land use activities of Surrounding Farmers and Hunting Tourism	Medium	Low
	Influx and mobile workforce contributing to spreading of HIV/AIDS	Medium	Medium-Low
	Impact on neighbouring property value	Medium	Low
	OPERATIONAL PHASE		
	Secondary Economic Boost	Low	Low to Medium(positive)

SPECIALIST FIELD	POTENTIAL IMPACT	SIGNIFICANCE: PRE-MITIGATION	SIGNIFICANCE: POST MITIGATION
	Contribution to the Namibian economy through taxes and royalties	Low	N/A
	Job Creation	Low	Low to Medium (positive)
	Influx of job Seekers and Employed adding to existing pressures	Low	Low
	Increased pressure on housing	Medium	Medium to Low
	Increased Traffic to Town and along private road to site	Low	Low
	Change to land use activities of Surrounding Farmers and Hunting Tourism	Medium	Low
	Influx and mobile workforce contributing to spreading of HIV/AIDS	Medium	Medium-Low
	Impact on neighbouring property value	Medium	Low
	DECOMMISSIONING PHASE		
	Secondary Economic Boost	Low	Low
	Loss of taxes and Royalties	Low	N/A
	Retrenchment of Operational Employees.	Medium to Low	Low
	Continuation of employment	Low	Low to Medium
	Change to land use activities by Surrounding Farmers and Tourism	Low	Medium (positive)

Conclusions and recommendations

While the consideration of alternatives resulted in the avoidance of some impacts, residual impacts that cannot be avoided still remain. The key ecological and social impacts related to the proposed construction and operation of the proposed mine can be summarised as follows:

- Impact on air quality, human and animal health and vegetation: Dispersion modelling results indicated that dust fallout and elevated PM and NO2 levels occur mostly at the mine site. Oxidation of sulphide, although calculated to be a main source of SO2, is expected to be a small contributor due to the various geochemical reactions taking place – the nature of the sulfide mineral being oxidized, the reaction mechanism and the presence of acid-consuming minerals. A large uncertainty exists around the emission strengths. Based on this, the degree of confidence is low resulting in Medium significance. Using low sulphur fuels in the vehicles, equipment and drier, the significance can be reduced to Low. Since the nearest dwellings are located some distance away from the mine, the significance of these emissions is expected to be low.
- Impact on groundwater and surface water hydrology: Sulphide in the ore and waste rock could result in groundwater contamination due to the formation of Acid Mine Drainage from tailings and stockpiles. The position of the TSF was therefore moved so that it is located on the carbonate rich rocks of the Swakop Group. The deep water levels and low hydraulic conductivity associated with these rocks together with the limited water in the dewatered tailings and addition of neutralising agents to the tailings adds to the security of the groundwater. Low inflow rates are estimated to the mine pit that could require neutralisation if found to be acidic. The general impact of the mine is seen to be of low significance if the recommended mitigation measures are implemented.
- Impact on fauna and flora: The most significant impact is the unavoidable land clearing that must be done at the start of the project. However careful landscaping and routing infrastructures around major trees, and revegetation once the mine is established can reduce the significance of the impact to acceptable levels. The initial concern regarding bird collisions with the new power line were found to be of low significance and no mitigatory actions are recommended. Overall the impact of the proposed project is expected to be of low significance.
- Impact of the project on the socio-economic environment: The project is expected to make several positive contributions the economy of Otjiwarongo and Namibia and cumulatively, will contribute to Namibia reaching its Vision 2030

goals. However, some negative impacts such as the expected influx of people to town and the associated pressures of this on the town's infrastructure and services require the implementation of the recommended mitigation measures. Nevertheless, it is concluded that the positive impacts resulting from this proposed project will outweigh the negative ones.

Key Recommendations

The TSF

According to Namib Hydrosearch (2014) the performance of the seepage control measures are to be evaluated and monitored with the wet disposal option. The indication of higher seepage rates than expected would require the following actions:

- "Measures to contain and recovery of water from the TSF cells during the start-up stages.
- Installation of recovery boreholes for retrieval of the effluent without affecting downstream groundwater users. Recovery boreholes may be required if seepage through or below the embankments is recorded with development of a phreatic water surface in the tailings.
- If monitoring of water levels and seepage quality indicates leakage through the bedrock underlying the TSF, the possibility shifting to dry tailing disposal has to be considered."

These recommendations apply if all the sulphides are disposed in the TSF and are not removed during rutile recovery. Removal of the sulphides will make the tailings more inert.

The type of TSF cover (seal) design will depend on the monitoring information and experience gained during the operation stage of the mine. However, placement of a low permeability seal on the TSF is the preferred measure. This method limits the possibility of rainwater infiltration and salt accumulation at surface by capillary action. Large quantity of clay rich material is required for the proposed 1m thick cover that may not be available locally. Other material such as compacted calcrete is to be evaluated.

Various methods exist that can reduce the impact of wind erosion. If a seal is placed on the TSF, it will need to be covered with a thin layer of topsoil to allow for the re-establishment of vegetation. Alternatively, rock cladding can be used on top of the seal. Any approach that either binds the particles together or make them more resistant to wind erosion, or reduce to the force of the wind will result in a reduction in windblown dust emissions (Airshed Planning Professionals, 2014).

The RWD

The RWD needs to be lined as suggested in Gecko (2014) with strip drains to prevent seepage. Steps will also have to be taken to minimise the retention time in the RWD and to pump this water as a priority for use in the plant. The RWD will be designed to accommodate storm water and to contain surface runoff from the TSF. Dilution of the effluent to a significant level is expected under these conditions.

Waste rock stockpile

"Diversion of stormwater drainage from the stockpiles with berms and peripheral trenches to collect seepage water and close monitoring is recommended. The addition of pulverised limestone (marble) to the stockpile to raise the pH and precipitate metals in the long term is recommended. On closure of the mine the stock piles are to be graded to encourage runoff and limit infiltration. The surface is to be covered with soil and vegetated. The protective berms diverting surface flow are to remain to avoid any erosion of the soil cover (Namib Hydrosearch, 2014)."

ROM stockpile

"Diversion of storm water drainage with berms and peripheral trenches to collect seepage water and close monitoring is recommended. On closure of the mine the stock piles are to be graded to encourage runoff and limit infiltration. The surface is to be covered with soil and vegetated. The protective berms diverting surface flow are to remain to avoid any erosion of the soil cover (Namib Hydrosearch, 2014)."

Workforce

A 'Locals First' policy should be adopted. The hierarchy to be followed starts at Otjiwarongo, then the region and then only can candidates be considered at a national level. During the construction phase, it is highly recommended that locals and Namibians be used rather than a foreign contractor. Not only will this contribute to the economy and job creation, but also limit the potential for the spreading of disease and impact on local housing and services in Otjiwarongo.

Construction workers should be accommodated in town, and not on-site. This will limit security risks such as poaching, limit the need for the construction of infrastructure for services on–site and encourage local spending in town.

Final Conclusion

The impacts associated with the proposed graphite mine can be reduced to acceptable measures. However, it is important that the measures provided in the EMP and associated management plans are implemented and monitored.

It is therefore recommended that the project receive Environmental Clearance, provided that the EMP is implemented.

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Abbreviations and Acronyms

ABBREVIATION/ ACRONYM	DESCRIPTION
ABA	Acid Base Accounting
ADT	Articulated dump truck
AMD	Acid Mine Drainage
AQG	Air Quality Guidelines
BID	Background Information Document
CBD	Central Business District
CITES	Convention on International Trade in Endangered Species
DEA	Directorate of Environmental Affairs
EA	Environmental Assessment
EAP	Environmental Assessment Practitioner
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
ELAW	Environmental Law Alliance Worldwide
EMP	Environmental Management Plan
EP	Equator Principles
EPA	Environmental Protection Agency
EPL	Exclusive Prospecting License
FEL	Front End Loader
GDP	Gross Domestic Product
GHG	Greenhouse Gasses
GN	Government Notice
HDPE	High-density Polyethylene
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
HQ	Hazard Quotient
I&AP	Interested and Affected Party
IAAO	International Association of Assessing Officers
ICU	Intensive Care Unit

ABBREVIATION/ ACRONYM	DESCRIPTION
IFC	International Finance Corporation
IT3	World Health Organisation Interim Target 3
MAWF	Ministry of Agriculture, Water and Forestry
MC	Mining Claim
MET	Ministry of Environment and Tourism
MW	Megawatt
NO2	Nitrogen Dioxide
NOX	Generic term for mono-nitrogen oxides NO and NO2 (nitric oxide and nitrogen dioxide)
OEHHA	Office of Environmental Health Hazard Assessment
PM2.5, PM10	Particulate Matter up to 2,5 or 10 micrometers in size
PPM	Parts per million
PS	Performance Standard
RFC	Reference Concentrations
ROM	Run of Mine
RWD	Return Water Dam
SA NAAQS	South African National Ambient Air Quality Standards
SAIEA	Southern African Institute for Environmental Assessment
SANS	South African National Standards
SO2	Sulphur Dioxide
TDS	Total Dissolved Solids
TOR	Terms of Reference
TPA	Tons per annum
TPH	Tons per hour
TSF	Tailings Storage Facility
US EPA	United States Environmental Protection Agency
UNFCCC	United Nations Framework Convention on Climate Change
UPVC	Unplasticized Polyvinyl Chloride
VOCS	Volatile Organic Compounds

ABBREVIATION/ ACRONYM	DESCRIPTION
WEC	Walmsley Environmental Consultants
WHO	World Health Organisation

1 Introduction

1.1 Background

The Okajande graphite deposit is situated approximately 14 km south of Otjiwarongo in the Otjozondjupa region (Figure 1-1). The reserve has been determined as 34 million tons of graphite ore, contained mainly in flake form with an average carbon content of 5.14%, providing a consistent supply of high grade, large flake graphite.

Gecko Graphite has obtained the mineral rights over the deposit, and is now in the process of updating the previous studies done by Rössing Uranium Limited (the former owner) in the 1990's.

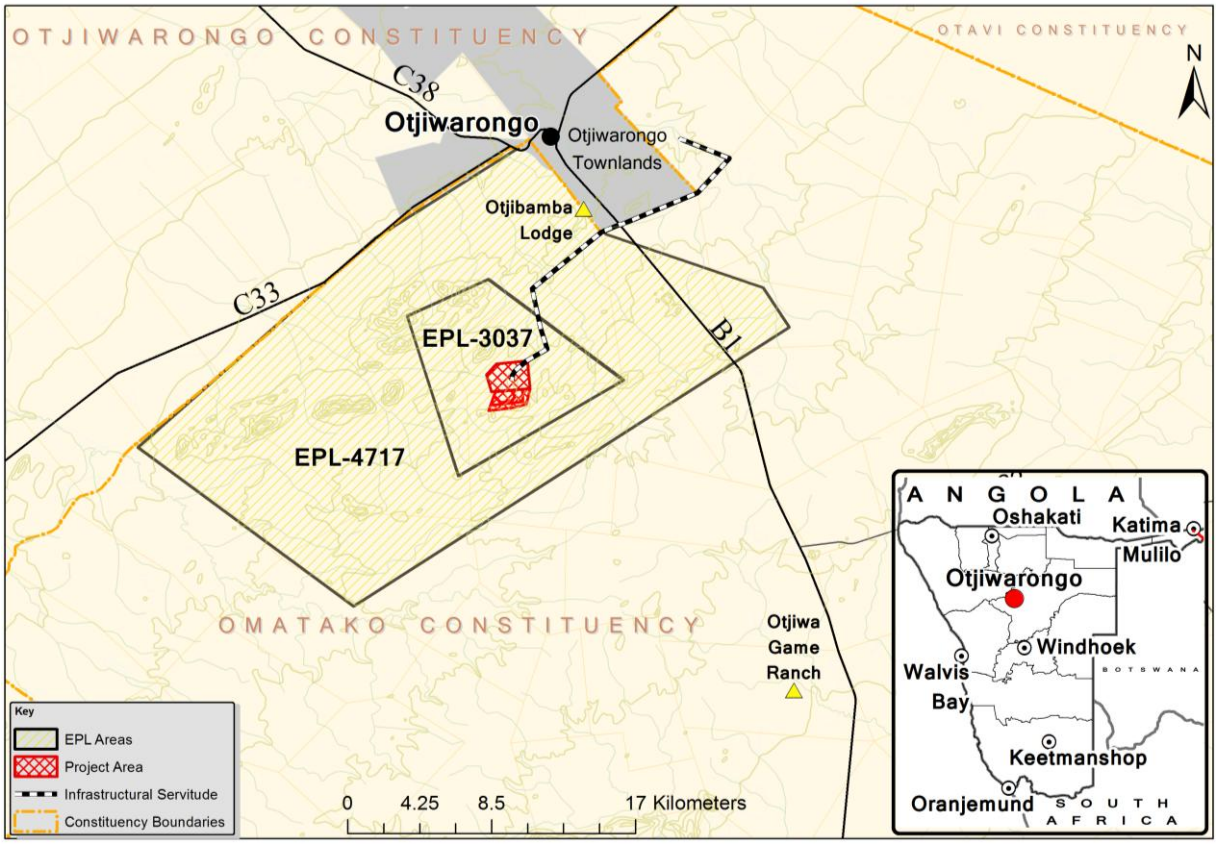

Figure 1-1: Locality map of the Okanjande deposit and proposed mining activities.

To satisfy the requirements of the Namibian Environmental Management Act (No 7 of 2007) and its Regulations (2012), Gecko has appointed Enviro Dynamics to update and expand on the previous EIA. The updated documents then need to be resubmitted in order for the project to obtain an Environmental Clearance Certificate from the Ministry of Environment and Tourism (MET).

1.2 Rationale

Graphite is an excellent conductor of heat and electricity and possesses high natural strength and stiffness. It maintains its strength and stability to temperatures in excess of 3,600°C and is inert even in hydrofluoric acid. At the same time it is one of the lightest of all reinforcing agents and also has a high natural lubricity.

Properties of natural graphite

- Electrical conductivity
- Thermal conductivity
- Refractory nature
- Resistance to thermal expansion and shock
- Chemical inertness
- Lubricating properties
- Insulating properties (when exfoliated)
- Low oxidation rate

Because of these properties, graphite is used in refractories, brake linings, foundry operations, lubricants, batteries, pencils, etc. Of these, it is particularly the refractory industry and lubricants that require high quality flake graphite, such as that found at Okanjande.

Graphite is regarded as an essential and strategic commodity due to its key industrial applications in a very specialized market. Because of the present market price and increasing demand of graphite, Gecko Graphite intends to secure a position in the market as a reliable supplier of high quality natural flake and powder graphite over a wide range of products. The target markets of these products are South Africa, America and Europe.

During the second phase of the project, value will be added by upgrading a portion of the graphite concentrate to a high-purity product through a leaching process. Other value adding possibilities include the manufacturing of semi-finished products like sheet and exfoliated graphite, expandable graphite, the production of specialized graphite size fractions, etc.

1.3 Appointed Environmental Assessment Practitioner (EAP)

In accordance with the Environmental Management Act (2007) of Namibia (and its regulations (2012)), an Environmental Assessment is required for

- "The construction of facilities for any process or activities which requires a license, right or other form of authorisation, and the renewal of a license, right or other form of authorisation, in terms of the Minerals (Prospecting and Mining Act), 1992."
- "Resource extraction, manipulation, conservation and related activities."
- "Other forms of mining or extraction of any natural resources whether regulated by law or not."

- "The construction of facilities for the transmission and supply of electricity"
- "Construction of industrial and domestic wastewater treatment plants and related pipeline systems."

For this reason, Gecko Namibia appointed Enviro Dynamics as independent environmental consultants to conduct the Environmental Assessment on their behalf. Eloise Carstens of Enviro Dynamics is the EAP who conducted the assessment. Her CV is attached as APPENDIX A.

1.4 Terms of Reference

According to the Terms of Reference provided by Gecko Graphite, the aims of the EIA are twofold:

- Firstly, it is being conducted in accordance with Namibia's Environmental Management Legislation (Environmental Management Act, 2007) and its Regulations (2012). The intent of the EIA is to provide sufficient information for the Directorate of Environmental Affairs (DEA) to make an informed decision about whether or not an Environmental Clearance Certificate should be issued.
- Secondly, the information provided in the EIA should conform to the standards of international financial institutions so that it can be included in Gecko Graphite's bankable feasibility study. Therefore, this EIA is designed and is being carried out to fulfil the Performance Standards prescribed by the Equator Principles (EP) and the International Finance Corporation (IFC). Under the EP and based on the IFC's categorisation process, all projects must be categorised depending on their environmental and social risk. The Okanjande project falls under Category A, which include projects "with potential significant and adverse social or environmental impacts which are diverse". More details about legislative requirements for this EIA process and project are provided in Section 5.

The process as prescribed by the Environmental Regulations (2012) covered the following steps, which are reported on in this document as follows:

- Provide a detailed description of the proposed activity;
- Identify all legislation and guidelines that have reference to the proposed project;
- Identify existing environmental (both bio-physical and socio-economic) conditions of the area in order to determine their environmental sensitivity;
- Inform Interested and Affected Parties (I&APs) and relevant authorities of the details of the proposed development and provide them with a reasonable opportunity to participate during the process;

- Consider the potential environmental and social (including biological) impacts of the development, and assess the significance of the identified impacts.
- Outline management and mitigation measures in an Environmental Management Plan (EMP) to minimize and/or mitigate potentially negative impacts and formulate a closure plan for the mine.

1.2 Work plan for study

In order to meet the requirements of the Terms of Reference for the EIA, the work plan for the study was determined as indicated in Figure 1-2.

Since the scope of the EIA was largely established during the 1993 EIA and subsequent gap analyses performed by SAIEA it was decided that the first phase of the EIA (scoping phase) would be concluded in a consultation document and not the typical scoping report. The consultation document reported on the updated consultation and disclosure initiatives undertaken and was circulated for public review.

This document (EIA) elaborates on environmental parameters identified during the previous phase (Scoping Process) as requiring additional investigation by specialists in the various fields.

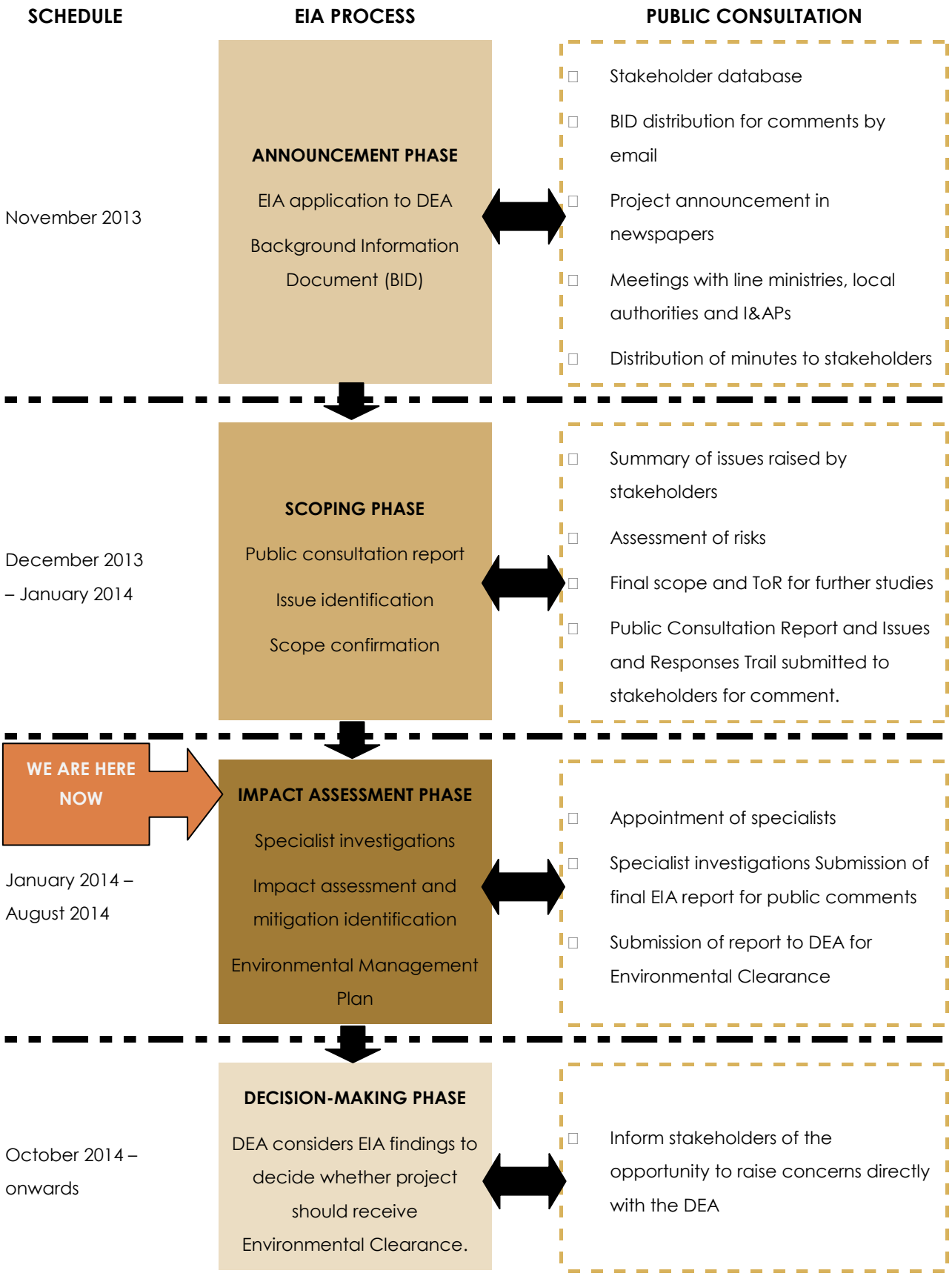

Figure 1-2: Diagrammatic summary of work plan.

2 Project Description

2.1 Project Overview

Approximately 70% of the world's graphite is produced by China with little graphite supplied from elsewhere in the world. According to Feytis (2010) Africa has important as yet undeveloped graphite deposits notably in South Africa, Mozambique, Tanzania, Ethiopia, Madagascar and Namibia. Many of these deposits have high flake content, suitable for further purification.

In Namibia, some exclusive prospecting licences (EPLs) have been granted to explore existing graphite deposits. However, despite the Aukam Graphite Mine near Bethanie which ceased operation in 1974, graphite is not currently mined in Namibia (Spilpunt, 2012). If a niche could be established on the world market for high quality graphite, considerable value can be added to the development of this mineral resource in Namibia.

Realizing the potential, Gecko Graphite, a Namibian owned and operated company, proposes to develop a graphite mine and processing operations near Otjiwarongo in the Otjozondjupa region of Namibia. The Okanjande graphite reserve comprises an ore body extending to a depth of at least 80 m. From beneficiation of the graphite on site, final products various sizes and qualities of flake and powder graphite that could be exported to markets in South Africa, America and Europe to be used in a range of industrial applications.

2.1.1 Locality

The Okanjande deposit is located 14 km south of Otjiwarongo, straddling the boundaries of two privately owned farms namely Highlands and Okanjande (see Figure 1-1). The mine pit will be located on Highlands, which belongs to Mr Landsrath whereas the other components of the mine operations will be established on the farm Okanjande, owned by Mr Praetorius. The required portions of Okanjande and Highlands will initially be leased from the respective owners while the possibility of acquiring ownership to the land is still being investigated.

2.1.2 Project history

In 1990 Rössing Uranium Limited became aware of the occurrence of flake graphite on a group of farms just south of Otjiwarongo. Subsequent reconnaissance geological examinations revealed substantial amounts of good quality flake graphite particularly on the farms Okanjande and Highlands (Van Eck and Lurie, 1993).

Between 1991 and 1993 Rössing Uranium Limited undertook a number of detailed studies pertaining to the project including a feasibility study and an EIA. A pilot plant and tailings dam was established in some distance from the site while extensive exploration drilling and trial mining operations were carried out on the ore body.

Apart from the typical EIA requirements (e.g. consultation with I&APs and impact assessments) the comprehensive study also included:

- monitoring of operations at the pilot plant including chemical and physical testing of tailings, revegetation trials on the tailings, storm-water erosion control, topsoil removal and stockpiling, natural revegetation at the mine site, and the taking of air and water quality samples;
- detailed studies on climatic conditions, soil, water quality, groundwater conditions, so-economic impacts, surface hydrology and archaeology and fauna and flora;
- investigation of alternative routes for road, pipeline, and power lines, process technology alternatives and pollution prevention techniques; and
- extensive test work on the geochemistry of the ore body, including acid-base accounting and tailings analysis.

Despite the positive results from the exploration and trial mining, as well as the pilot plant, an unexpected collapse of the graphite price on the world market resulted in the termination of the project in 1993.

In recent years, with the stabilization of graphite prices and a marked increase in demand, several companies showed renewed interest in the Okanjande deposit. Gecko Graphite however obtained the right to commence with mining activities on the site.

2.1.3 Mineral licences

Gecko has obtained the rights through Mining Claim (MC) 66249 (which was granted to the company on 30 October 2012) and the mineral exploration rights through EPL 3037 (transferred to Gecko Graphite on 6 August 2013) and has recently also applied for the surrounding area with EPL 4717. Although the current project is located only on MC 66249 and EPL 3037, prospecting operations may be extended to the wider area as delineated by EPL4717 subject to approval by the Ministry of Mines of Energy.

What is an EPL?

The holder of an Exclusive Prospecting Licence (EPL) shall have the sole right of prospecting for the mineral (s) specified for the licence and within the area of his licence.

The licence holder does not need to own the land but must notify the landowner or occupier before entering. The licence is valid for three years and may be renewed on application for a further two years at a time.

Minerals (Prospecting and Mining) Act, Act 33 of 1992

2.2 Project components and phases

The proposed project consists of the following main components. These are presented in Figure 2-1 below:

- Mining operations – comprising of open cast mining by drill and blast, ore stockpiles, waste dump area, transportation infrastructure and crusher.
- Processing operations – comprising of the milling and ore conditioning facilities, and the processing plant, all adjacent to the mine pit and associated pipeline and other infrastructure routings, product packaging and storage facilities.
- Tailings disposal – Tailings Storage Facility (TSF) with associated disposal and drainage infrastructure, monitoring and pipe infrastructure.
- Product transport and shipping – including the main access points to and from the site, main transportation routes to either Otjiwarongo or Windhoek and railway access.
- Small-scale mining of marble rocks for pH control.
- Mining of construction material (calcrete) for road building.

The project will take a staged approach:

- 2013-2014 – environmental authorization process and feasibility study;
- 2015 – construction phase of 14 months (to commence subsequent to environmental authorization);
- Phase 1 - first four to ten years of mining. Initially the mine will operate at a maximum depth of 18 m. Only the weathered or oxidized zone of material will be utilized during this phase. Therefore there will be a low risk of generating Acid Mine Drainage (AMD). The mining rate during this initial period is estimated at 210,072 tons per annum excluding approximately 17% of waste rock.
- Phase 2 –mine pit will be extended to 85 m (maximum depth after 70 years). The mining rate during this period will be 420,143 tons per annum excluding the 17% waste (unmineralized rock).

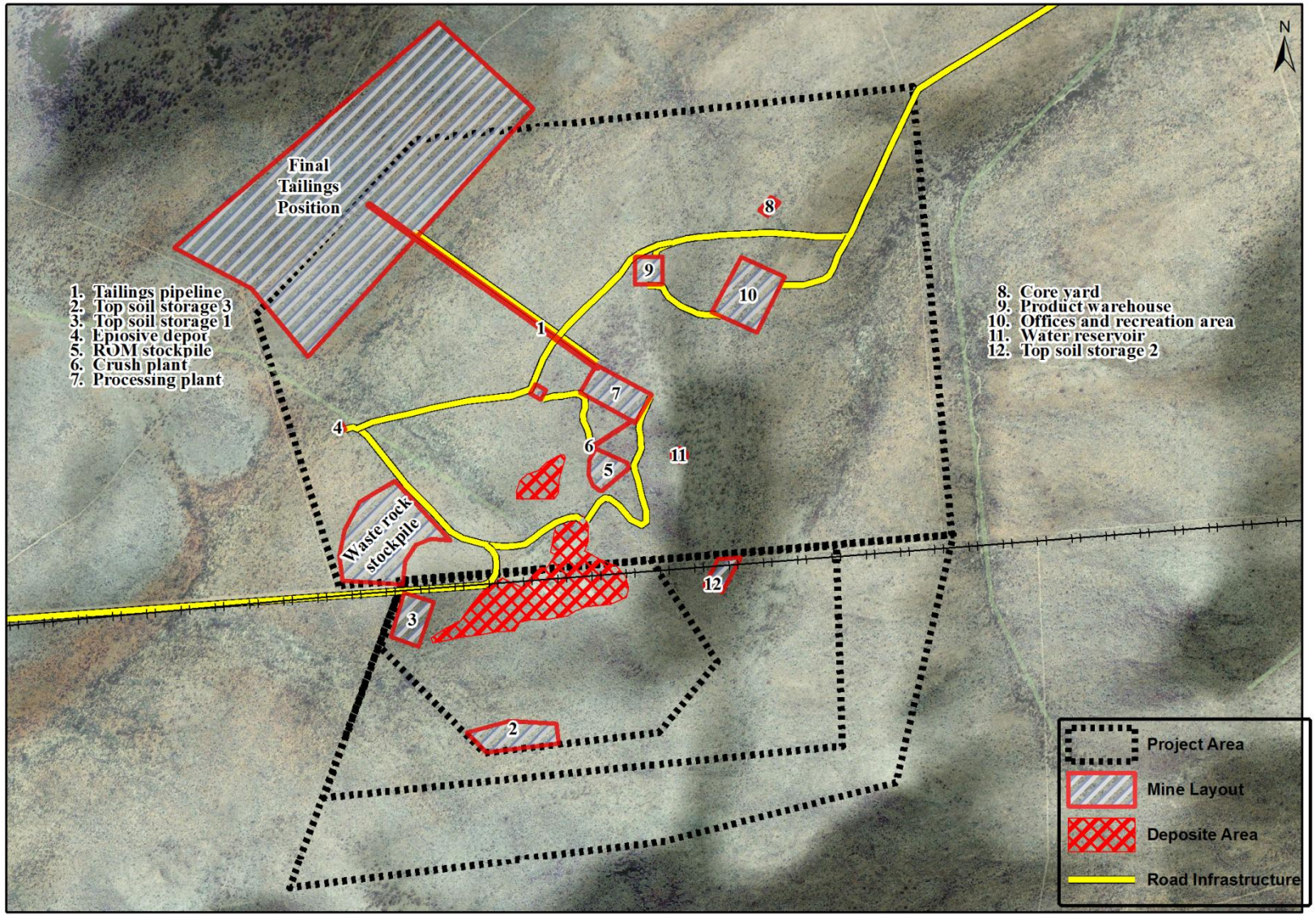

Figure 2-1: Proposed site lay-out of the mining and processing works.

2.3 Mining operation

2.3.1 Mineral Resources

The local geology of the study area is complex. The ore body is hosted in quartzites and feldspathic quartzites of the Nosib Group (Figure 2-2 and Figure 2-3) which are the oldest rocks in the Damara Sequence (850 to 700 million years). The fresh ore is characterized by extensive sulphide mineralization. The ore is comprised of graphite-rich, micaceous, quartzose-feldspathic gneiss and two main ore types (fresh and weathered) can be distinguished (Van Eck and Lurie, 1993).

Below the surface is weathered ore, where oxidation of the sulphides has penetrated to a depth of approximately 18m. The second layer is called fresh or un-oxidised ore. If exposed to oxygen these un-oxidised rocks may become acid generating, a phenomenon known as Acid Mine Drainage (AMD).

> ***What is AMD?***
>
> *Acid mine drainage (AMD) occurs during mining activities where sulphide minerals are brought to the surface. When exposed to water and the atmosphere these oxidize form sulphuric acid. This process is called acid mine draining because it commonly results in acidic waters draining away from the mine dump sites.*

Marbles, calc-silicates and biotite schists of the lower Swakop Group also occur in the area. Some of these rocks have an inherent acid neutralizing capacity and the possibility of utilizing those for the conditioning of the ore as well as for the deposition of the mine tailings was investigated as part of the water specialist study.

In order to define the graphite ore reserves, 80 exploration boreholes were drilled during Rössing's exploration project (Van Eck and Lurie, 1993). Approximately the same number of holes has been drilled by Gecko to date. The exploration work established the dimensions, quality and tonnage of the ore body.

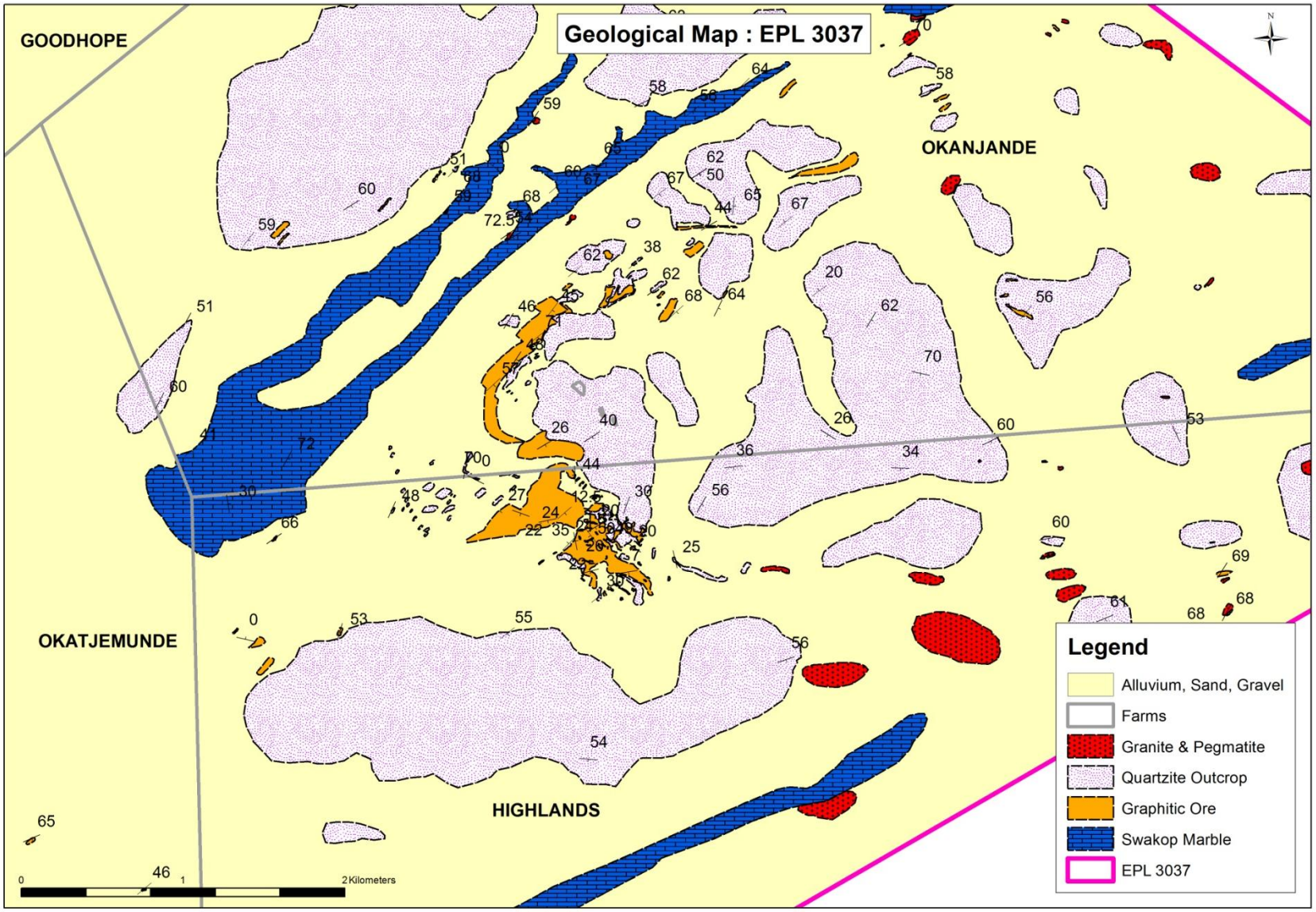

Figure 2-2: Underlying geology of EPL 3037.

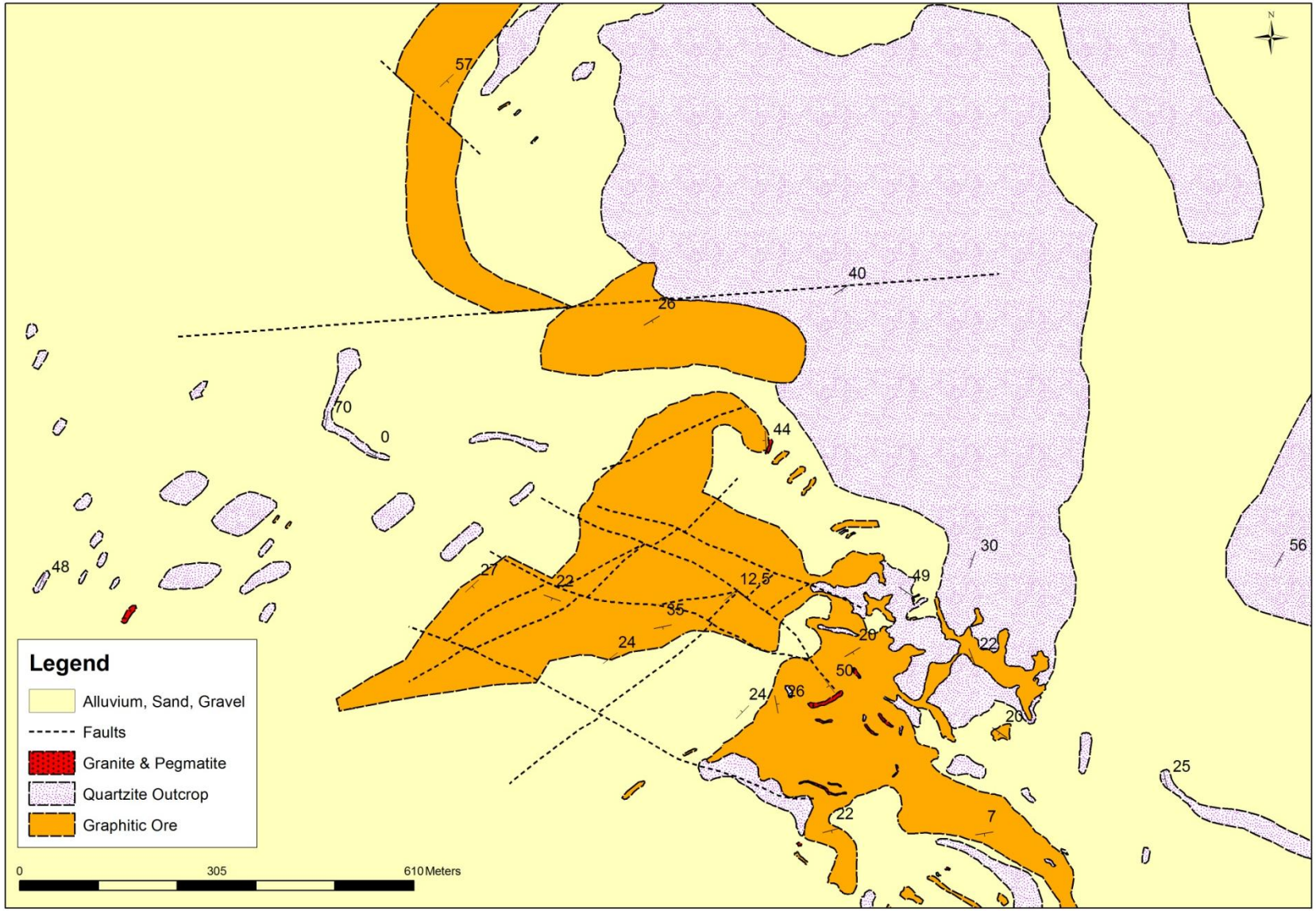

Figure 2-3: Underlying geology of the Okanjande deposit.

The resource was described by Rössing as shown in Table 2-1. With this reserve potential the mine has a projected life of mine of a minimum of 70 years.

Table 2-1: Description of the reserve potentials of the Okanjande deposit.

	DEFINITION	OKANJANDE POTENTIAL		
		RESERVE	% GRAPHITE	% CUT OFF/STRIPPING RATIO1
DEMONSTRATED GEOLOGICAL RESERVES	The in-situ grade and tonnage of rock identified as graphite ore within the limits of the geological model	34 million tonnes of graphite ore	5.14% graphite	---
INFERRED GEOLOGICAL RESERVES	Additional reserves based on projections below the bottom of boreholes.	4.4 million tonnes of graphite ore	6.8% graphite	---
MINING RESERVES	Ore tonnage which include the geological reserves and a certain planned amount of waste rock.	10.3 million tonnes2	Averaging 6.1% graphite	Stripping ratio3: 0.17:1, 2% cut off
	1Stripping ratio: 0.17:1 means that mining one cubic meter of ore will result in mining 0.17 cubic meters of waste rock. 2Applies to an open pit designed for 25 years of operation at a production rate of 20 000 tonnes of concentrate per annum. 3% cut-off: Refers to the level of mineral in an ore where it is no longer economically feasible to mine it.			

Graphite occurs in a variety of forms. Concentrates of the mineral exhibit a range of carbon contents and specific properties that vary from deposit to deposit because of the nature of the mineral and its impurities. Production from the Okanjande deposit will be flake and powder graphite in a ratio of 55% to 45%.

Flake Graphite

Is found disseminated in the host rocks as individual, well crystallized flakes of carbon.

Powder Graphite

Is the fine crystalline graphite mineralization. The product is usually made up of 75 to 100% of flakes finer than 120µm.

Prices on the market are mostly determined by flake size and carbon content. Coarse flakes with a high purity will obtain substantially higher prices than powders with low carbon content. Coarser flakes can be ground to create powder graphite. Over 55% of the graphite in the Okanjande deposit occurs as well crystallised, undeformed flakes, disseminated throughout the rock along grain boundaries with an average flake size of more than 150µm in diameter (i.e. coarse) (Table 2-2).

Table 2-2: Summary of characteristics of flake graphite, compared to that of the Okanjande deposit.

	DEFINITION	ADAPTED FROM MITCHELL (1993)	OKANJANDE GRAPHITE
FLAKE SIZE	Size of the individual graphite crystals. The larger the flake size, the higher the purity.	Crystalline flakes; coarse >150 – 850 µm; fine <150µm mesh	55% of the average flake distribution is predicted to be >150 µm, i.e. coarse.
ORE GRADE	Weight percentage of graphite in the host rock.	5-20% graphite, other known global deposits are below 10% and are typically in the 2 – 6% range	6.1% graphite of the mineral reserve
PRODUCT GRADE	Determined by the graphitic carbon content of the concentrate.	Typically 75-97% carbon	94-98% graphite
IMPURITIES	Fine materials (such assillicates or sulfides) may coat the graphite, making it difficult to remove during preparation. This may reduce the quality and thus	Typically include minerals found in metasediments usually quartz, feldspar, mica, amphibole, garnet and calcite.	The graphite from Okanjande has little impurities which is apparent in the high product grade.

	DEFINITION	ADAPTED FROM MITCHELL (1993)	OKANJANDE GRAPHITE
	value of the final product.		
MAIN USERS	Main applications of graphite.	Refractories, brake linings, lubricants and batteries	Because of the flake size and purity, the graphite from Okanjande could be used in most applications.

According to Mitchell (1993) separating the graphite from its host rock is easier if the flake sizes are coarse because the amount of crushing and grinding prior to mineral separation is minimised. This is related to the level of fines or impurities in the graphite concentrate. Fine flake sizes may coat other mineral which the concentrate together with the graphite during processing and therefore will get recovered as part of the graphite concentrate. Thereby the grade of the final product is reduced.

2.3.2 Mining method

The mining method selected for the project is a conventional open cast mine by means of drill and blast operations. Vegetation, topsoil and overburden will be stripped and stockpiled for future use in rehabilitation and landscaping. Once the mineralized and waste rock is fragmented, it gets loaded onto haul trucks and transported to the Run of Mine (ROM) stockpile.

Blasting will not occur every day. After drilling the blast holes are charged with explosives and the rock fragmented by blasting. Blast-holes are 89mm in diameter and each hole/bench is 5.70m deep/high. 117 holes will be drilled per day. 4.04m3 of rock is broken per meter drilled, therefore 664m need to be drilled per day. Tremors will be felt in a radius of 500 meters from the pit.

It is expected that blasting operations will only occur two to four times per year to produce the entire year's Run-of-Mine of 188 000 m³/annum. Blasting is an instantaneous occurrence and even though the visible impacts from blasting are significant on the mine site, the health impact (mainly dust generation) is low due to the short duration of the blasts.

During the first ten years (Phase 1), only the weathered or oxidized zone of material will be utilized to a maximum depth of 18 m. This will present a low risk of generating Acid Mine Drainage (AMD). After this period, the depth of the pit will over time be extended to 85 m (maximum depth after 70 years) to include the unoxidized material (Table 2-3).

Two alternative methods are considered regarding the rate at which the ore will be mined from the pit. These are discussed in more detail in Chapter 3.

Table 2-3: Mining and waste disposal rates during the respective phases of the project.

	DEFINITION	DURING THE PROJECT
MINING RATE	Monthly or annual tonnage that is recovered from the deposit during mining including the waste rock.	491 568 tons/annum
RUN OF MINE (ROM) STOCK PILE	Ore from the mine for processing.	425 000 tons/annum
WASTE ROCK	Barren rock or mineralized material that is too low in grade to be economically processed.	75 000 tons/annum
GRAPHITE PRODUCTION	Graphite concentrate product	20 000 tons/annum
TAILINGS	Material rejected from the processing plant after most of the recoverable valuable minerals have been extracted. Normally consists of ground-up rock in the sand to silt size range.	405 000 tons/annum

The open pit will be developed in 5 m benches and an overall standard slope angle of about 60˚ to provide the necessary rock mechanical control. The final surface area will be roughly oblong in shape and approximately 900 m by 700 m with a maximum pit depth of 85 m (Figure 2-4).

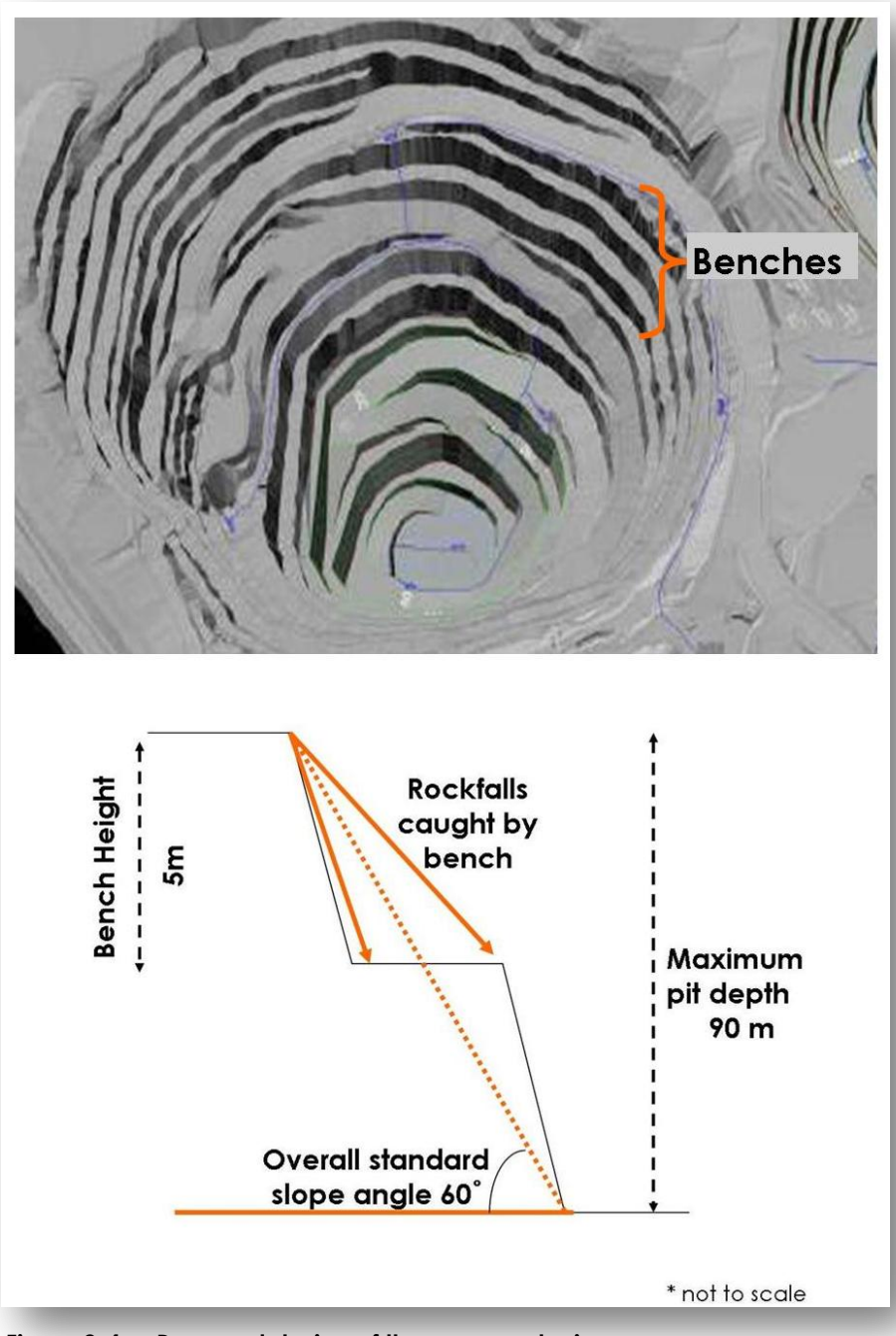

Figure 2-4: Proposed design of the open cast mine.

The ore will be loaded onto dump trucks for haulage to the stockpiles at the primary crushers and the waste rock will be taken to the waste rock dump (Figure 2-1).

- ***Run Of Mine (ROM) stockpiles***

A large ROM stockpile is required from where the plant's feed will be reclaimed at 220 tph minimum to 350 tph maximum. The stockpile has to be in close proximity to the crusher and the processing plant in order to minimise the hauling distance. A site has been selected for the ROM stockpile 162m south of the processing plant (Figure 2-1) with a footprint area of 13

000m2 and an estimated capacity of 80 300m3 or 128 480 ton. A 4 m high bund wall will be constructed to contain the ROM. 30-ton haulage trucks will dump the ROM from an access road 17.5m above the toe of the stockpile. The stockpile is constructed by dumping the 30-ton truckloads evenly along the width of the stockpile and then over-dumping these. A bulldozer will be used to flatten the dumps and push the ROM into the bunded area until the top of the stockpile is level or just above the access road. The final embankment height will be between 17.5 and 20 m.

Seepage from the ROM stockpile will be collected via perimeter trenches and routed to a dedicated collection dam. Rainwater will be diverted from the upstream slopes of the mountain away from the ROM stockpile. The acidity of the water in the collection dam will be monitored on a regular basis. The capacity of the dam will be such that it will be able to handle the 1-in-100 year rainfall of 160mm over a 24-hour period on the footprint area of 13 000m3, i.e. it will be able to hold 2 080m3 of rain water. The collection dam's return water pumping system will be designed to pump out the rainwater collected from a 1-in-5 year storm over a 24-hour period in 6 days, i.e. 6m3/h (65mm on the 13 000m2 equates to 845m3).

- ***Waste rock stockpile***

On average 17% of the mined tons is waste rock (i.e. 71 424 tpa). Over Phase 1 (37 year life of mine) a total of 2.64 million tons of such waste rock must be stockpiled. At a bulk density of 1.60 t/m3 the waste rock stockpile requires a minimum capacity of 1.65 million m3. The stockpile has to be located close to the opencast pit in order to minimise the hauling distance. The selected site (Figure 2-1) is 700m to the north of the mining pit and has a footprint area of 83 817m2.

The waste rock will be dumped along the base of the selected area with 30-ton haulage trucks. A 6m wide access road will then be formed with the waste rock at a gradient of 3:1 to allow over-dumping of the previously dumped piles. A bulldozer will flatten the dumps to allow for enough manoeuvre area for the trucks to over dump. The final height of the stockpile will be 25m.

Seepage from the Waste Rock stockpile is not considered to be acidic and will therefore not be collected in a dam, but will only be diverted away from the pit and ramp of the stockpile. Rainwater will be diverted from the upstream slopes of the mountain away from the Waste Rock stockpile. The rainfall of a 1-in-100 year storm event is 160mm on the footprint of the Waste Rock stockpile (i.e. 13,411m3). The water will be collected via perimeter trenches and diverted away from the mining pit and access roads.

- ***Equipment requirements***

The fleet of equipment required for the operation of the mine will include:

- three articulated dump trucks (ADT) (35 ton capacity),
- one loader,
- one drill rig,
- one dozer,
- one hydraulic breaker and
- one explosive truck.

The necessity to mine at depth to expose high grade fresh ore will mean restricted operational areas with steep ramps.

2.4 Processing operation

2.4.1 Processing Plant

As indicated in Figure 2-1 the processing plant is located approximately 400m north of the mine pit on the lower slopes of the ridge. An area of 6.2 ha (310 m x 200 m) will be fenced off to accommodate the plant and associated buildings.

2.4.2 Stages of processing

Crushing, grinding and beneficiation by flotation is the most recognized method of processing flake graphite (MEGA Graphite Incorporated, 2014). During the flotation process a series of cells is used to obtain a purer and purer concentrate (Figure 2-5). The process utilizes graphite's natural hydrophobic property to selectively separate it from the hydrophilic gang (i.e. materials that are attracted to water).

In the cells, frothing chemicals are added to produce the froth or foam on which the flotation process depends. This enables the graphite particles to attach to an air bubble and rise through the pulp to the surface of the froth. Even if the bubble was to break in the process, the hydrophobic property of graphite allows it to remain on the surface of the froth. Because the graphite flakes are now physically separated from the remaining pulp material, they can be removed for further processing. Collectors are often used in combination with the frothing chemicals to further enhance the hydrophobic properties. This further improves recovery by facilitating attachment to the air bubbles.

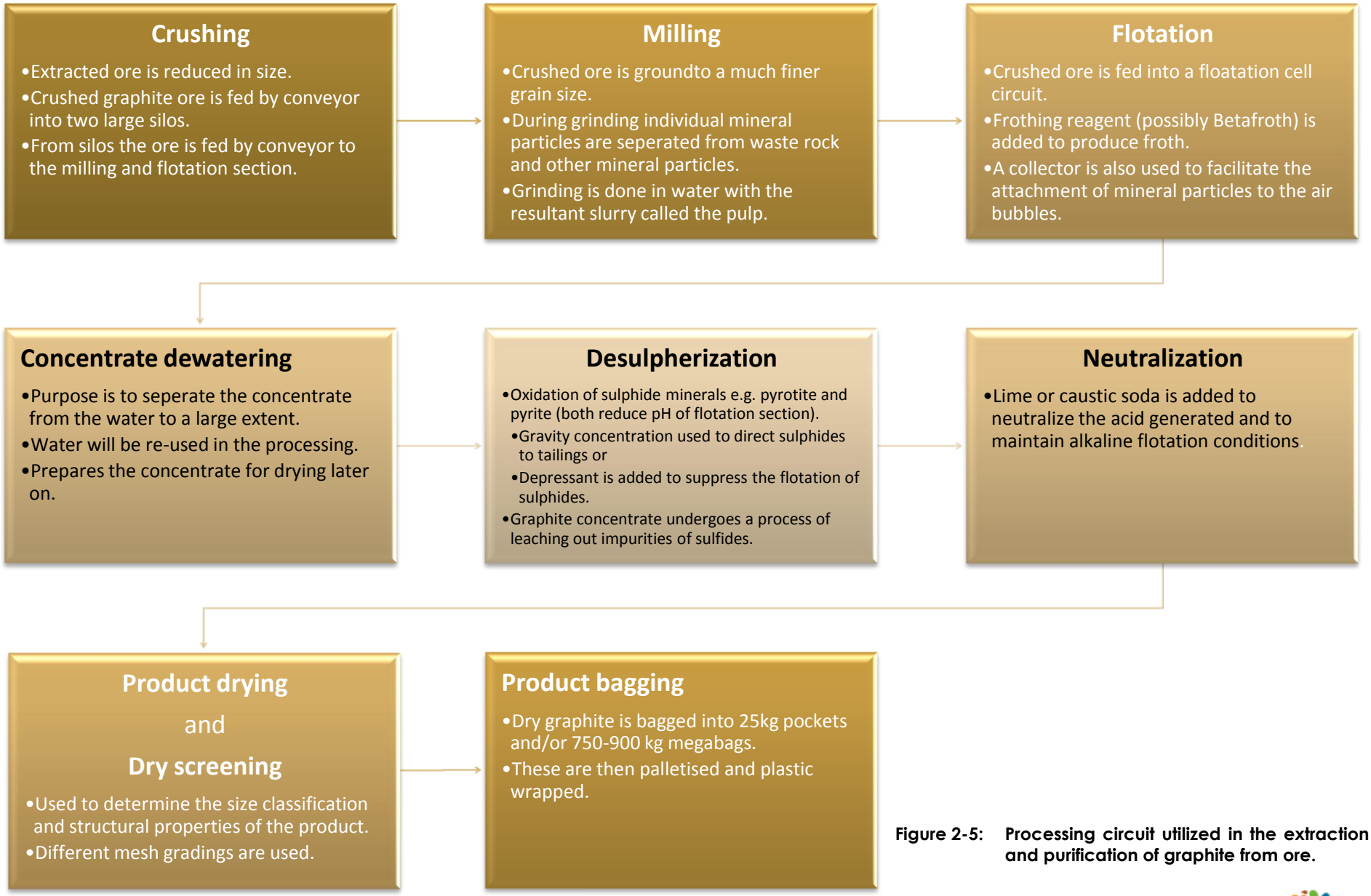

Figure 2-5: Processing circuit utilized in the extraction and purification of graphite from ore.

Once the flotation process has been completed the dried product can be screened, each with a certain flake distribution and carbon contents. Based on Van Eck and Lurie (1993) the Okanjande mine can produce the following grades (Table 2-4):

Table 2-4: Graphite grades obtained during the1993 pilot plant studies, projected quantities and envisaged production rate.

GRADE	% OF TOTAL PRODUCTION	TONNES/ ANNUM
Total 30 mesh (+600µm)	1%	203
Total 50 mesh (+300µm)	12%	2404
Total 80 mesh (+180µm)	32%	6401
Total 100 mesh (+150µm)	12%	2398
Total 150 mesh (+106µm)	20%	3999
Total Flake	77%	15405
Total < 150 mesh (-106µm)	23%	4595
Total < 200 mesh		
Total < 300 mesh		
Total < 400 mesh		
Total Powder	23%	4595
Total Sales	100%	20 000

1 mm = 1000 µm

2.4.3 Product storage and transport

The final product will be containerized on site and transported to the port at Walvis Bay by means of rail and/or road or the graphite pallets will be containerized in Walvis Bay prior to entering the harbour. Each container will be loaded with 28 tonnes of packaged product. The main markets for the graphite concentrate will be South Africa, USA and Europe.

Once operational, the processing plant will operate 52 weeks per year, five days per week, and 24 hours per day.

2.4.4 Rutile Recovery

Rutile is a common accessory mineral in high-temperature and high-pressure metamorphic rocks and in igneous rocks, such as is the case with the Okandjande graphite deposit. The main uses for rutile are the manufacture of refractory ceramic, as a pigment in paints, plastics and food, and for the production of titanium metal.

The rutile is a heavy mineral and will be recovered from the process stream via gravity concentration spirals. The recovery circuit consists of a drier, where the dewatered concentrate is dried at 100˚C. Thereafter, electrostatic and magnetic separators are used to separate the rutile from the gangue. The final product is then bagged in 25kg bags or 1-ton bulk bags. Normally no chemicals are used in this process, but in some cases floatation is required as an additional processing step.

Most of the sulphur bearing pyrite and pyrrhotite as well as the zircon and monazite will also report to this heavy mineral concentrate (Table 2-5). This will reduce the amount of acid drainage in the TSF because most of the sulphur bearing minerals will be collected onto the rutile concentrate stockpile, where the necessary precautionary measures will be taken to ensure that the ground water is not contaminated.

Table 2-5: Concentration of minerals expected in the processing of graphite

MINERALS	CONCENTRATION
Rutile content in the ROM	0.80%, I.e. 0.61 tph
Average sulphur content in the ROM (fresh ore)	2.50% I.e. 1.92 tph
Sulphur content in the graphite product	0.50% I.e. 0.0183tph
Sulphur tons recovered to tailings	1.90tph
Zircon & monazite content of the ROM	0.50% I.e. 0.38tph
Total heavy minerals recovered to the rutile stockpile	2.90tph or 15,865tpa

Of the 0.8% rutile available in the ROM only 50% will be recovered to the final rutile product, i.e. 0.31tph or 1,681tpa. It is estimated that 93% of the TiO2 in the feed will be recovered as saleable products, therefore rutile at 0.31tph and also leucoxene at 0.26tph or 1,445tpa.

At this stage Gecko is only requesting approval to stockpile the rutile rich concentrate, which will be recovered from the tailings before the material is transported to the TSF. The rutile rich concentrate will be recovered from the flotation circuit's tailings stream. This concentrate will

be stockpiled until sufficient quantities are available to batch operate a rutile beneficiation circuit at around 5-10 tph. The rutile beneficiation circuit will consist of a drier and electrostatic and magnetic separators as well as a screen classifier.

2.5 Tailings Storage Facility (TSF)

2.5.1 General

Typically, the bulk quantity of tailings consists of rock which is remaining after the processing and the extraction of the valuable mineralisation. The material is crushed and ground to a fine size ranging from fine sand down to silt (Particles ≤ 0.1 mm in diameter) and is mixed with water (Crowflight Minerals Inc. , 2007).

The Okanjande processing operations will be operated for 24 hours per day, 5 days per week totalling to 5 479 hours per year. The tailings produced will be as follows (Table 2-6):

Table 2-6: Mass flow at the processing plant.

	DESCRIPTION
MILL FEED RATE	76.69 tph or 420 143 tpa
GRAPHITE PRODUCT	20,000 tpa, average rate 3.65 tph or 76.66 tons/day
TAILINGS	400 143 tpa, average rate 73.0 tph and 1 534 tons/day.
DENSITY OF TAILINGS	1.35 ton/m3, therefore close to 300 000m3 per annum will be deposited onto the tailings facility
PHASE 1 (LIFE OF MINE OF 37 YEARS)	Total tailings production of 15 million tons or about 11 million cubic meters.

During the 1993 studies, various assessments were undertaken to determine the tailings properties and disposal requirements to store and manage the tailings for the life of mine. These reports as well as the 2014 Tailings Disposal Conceptual Design (Gecko, 2014) is available and was used as a foundation by the specialists appointed on the current EIA. A summary of the suggested values of the tailings for design purposes are provided in the table (Table 2-7) below:

Table 2-7: Summary of the properties of the tailings that will be produced.

	DESCRIPTION
DRY DENSITY IN PLACE	• As dumped, loose: 800 kg/m3 • After bedding down: 1,160 kg/m3

	DESCRIPTION
	• After consolidation: >1,350 kg/m3
MOISTURE CONTENT	15% Recommended, not to exceed 20% so as to ensure material is not saturated
SHEAR STRENGTH:	θ = 20°; c = 0°
PERMEABILITY AFTER CONSOLIDATION:	k = 1.2 x 10-5 m/s

The 1993 chemical analysis indicated that the tailings will contain pyrites and pyrrhotites independent on whether oxidised or unoxidised ore is mined. Since it is likely that these will be oxidised in time to produce highly acidic leachates (with significant pollution potential should they enter the groundwater) the tailings need to be managed, both during operation and after mine closure. Measures need to be put in place in order to prevent sulphide oxidation and the resultant acid generation.

2.5.2 TSF Location Considerations

The initial position of the TSF proposed during the 1993 assessments was investigated by the geohydrology specialist (Namib Hydrosearch, 2014). However, the RUL proposed site was found to be inappropriate because the site straddles a contact zone between the Nosib Group quartzite and the Swakop Group marble.

In the study, alternative locations were considered within a radius of 2 km from the processing plant.

The most important factors governing the placement of the TSF were:

- ❖ Ground water flow and permeability of the underlying rocks
- ❖ Acid – base accounting potential of the underlying rocks
- ❖ Wind, especially direction of strong wind events

These factors together with the alternative locations considered are discussed in further detail in the following chapter.

2.5.3 TSF Design

The following factors are considered in the design of the tailings dump and are discussed in further detail in Chapter 3 of this report:

FACTOR INFLUENCING THE DESIGN	DESCRIPTION
The quantity of tailings to be deposited	For design purposes 400,000 tpa for 50 years of operation. Provision is made for further extension areas for later or possibly increased production.
Site topography	The topography dictates the location and positioning of the site.
The method of depositing the tailings:	The tailings can be deposited wet (containing at least 50% water) or dry (containing a maximum of 20% water). Both methods are discussed in Chapter 3 of this report.
Allowable side slopes for establishment and maintenance of vegetation	No steeper than 1:3 (vertical: horizontal) or 33% slope.
Maximum side slopes and height for stability of the dump	The stability of the dump is governed by the strength properties of the dumped material, the degree of saturation of the material and the strength of the underlying foundation. These factors may dictate the allowable side slope and height of the dumped material.
Orientation, direction of construction and maximum height	Relates to the control of dust pollution. With the prevailing wind from the east, development of the dump should proceed downwind to the southwest. The proposed maximum height is 25 meter.
Storm water control measures.	Provision will be made to collect storm run-off from precipitation on the dump area and to divert runoff arising outside this area.

2.5.4 Tailings Disposal

Gecko does not yet have a final tailings disposal design. The instruction to the EIA team was to investigate the potential environmental impacts of both wet and dry tailings disposal. The outcome of the specialist investigations is then discussed with the client to comprehend the implications from an environmental, economical and technical perspective and to come to the best option.

According to the Environmental Law Alliance Worldwide (ELAW) (2010) there are two main alternatives for the disposal of tailings on land:

1. Use of a wet tailings impoundment facility or 'tailings pond'; and

2. Dewatering and disposal of dry tailings as paste backfill or 'dry tailings disposal'.

For this EIA, these alternatives are investigated in more detail in Chapter 3.

2.6 Ancillary works

2.6.1 Calcrete

In order to obtain access to the mine site the de-proclaimed D2515 will need to be upgraded from the B1 to the turn-off south towards the mine and along the farm boundary Okanjande / Osdam to the site. For this 12 kilometre road development Gecko will require calcrete as the main construction material.

The calcrete can be obtained from extending an existing borrow pit, which is situated just to the east of the B1 within the Otjiwarongo town lands (Figure 2-6). A total of approximately 1.3 hectares are envisaged for this excavation to a shallow depth of less than 2 metres. Gecko will ensure best practice in mining and environmental management as well as rehabilitation of the pit.

2.6.2 Marble Rock

Once in operation the graphite mine will require limestone for pH control in the processing of the ore. From the engineering studies it is anticipated that therefore approximately 5 kg of marble will be required per ton of graphite ore. As such 2 000 tons will be needed per year. Over the life-of-mine period approximately 100 000 tons will need to be sourced for this purpose. The anticipated footprint of such a marble excavation is calculated to be very small by mining standards. At a maximum mining depth of 10 m, less than 4 000m2 (0.4 ha) would be occupied by this pit after 50 years of mining. A potential site for such a quarry has been found south of the telecommunication hill (Figure 2-6). The request for the marble pit is still subject to licensing by the Ministry of Mines and Energy. The Environmental Clearance for this ancillary operation and open pit is applied for as one aspect of the larger development and after due regards given to it in the ground water study (Namib Hydrosearch, 2014). Gecko obtained principle approval on the matter from the Otjiwarongo Town Council that is the custodian of the land.

Gecko intends to develop the marble and calcrete excavations solely for the project's own requirements. No rock or construction material will be sold to any other parties from these sites.

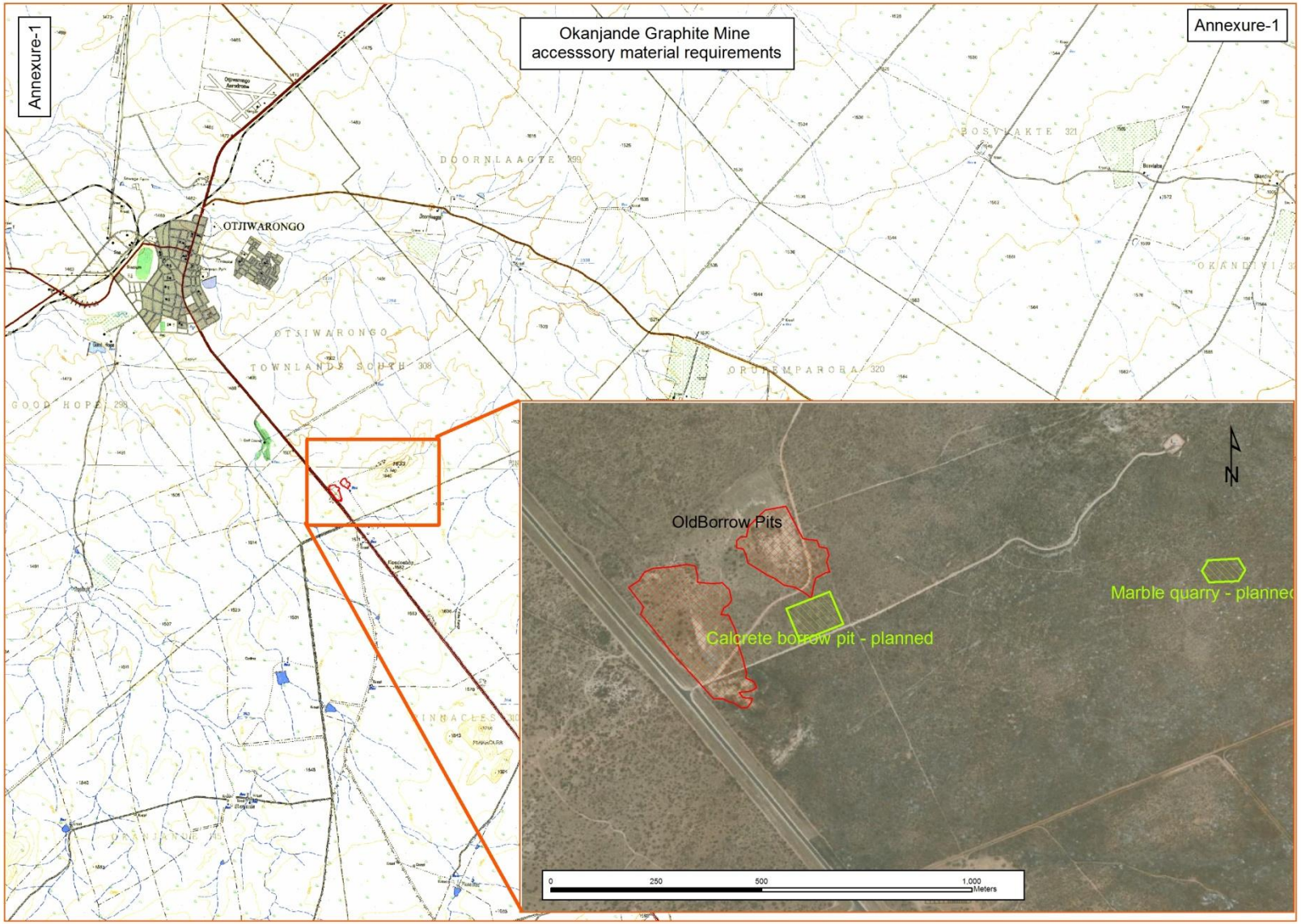

Figure 2-6: Locations from where the ancillary materials will be acquired (Created by Gecko).

2.7 Resource and infrastructure requirements

2.7.1 Water requirements

The water demand for the project during the first phase of implementation is estimated at 100 000 m3/year (approximately 18.54 m3/h or 380m3/day). This figure is likely to increase during the second phase of the project to a maximum demand of 150 000 m3/year (Table 2-8).

Table 2-8: Water requirements expected during operations of the mine.

	M3/H	M3/DAY
PROCESS (RAW)	18.1	380
POTABLE (INCLUSIVE)	0.68	14.3
CONTINGENCY	+20% contingency	
TOTAL	21.7	456

2.7.2 Water collection and distribution systems

- ***Abstraction boreholes***

During the 1993 studies a number of water sources were investigated including the Omarassa-Otjiwarongo Regional State Water Scheme in combination with several boreholes. At that point, the water levels of the Water Scheme were however already prone to over-abstraction. Although the EIA concluded that sufficient supplies of water can be obtained from nearby sources, local supplies were found to be limited.

Based on the previous studies in the area and on the capacity of bulk water sources supplying water to Otjiwarongo, groundwater was found to be the most likely source of water for the mine (NamWater, 2011). Consequently, in 2012 an independent firm of groundwater consultants investigated available groundwater sources in the area (Namib Hydrosearch, 2012). Following an exploration program, three boreholes were found that yielded positive test pumping results (i.e. the boreholes were found to yield a sustainable supply of good quality water) (Figure 2-7). These boreholes are all located on the Farm Doornlaagte.

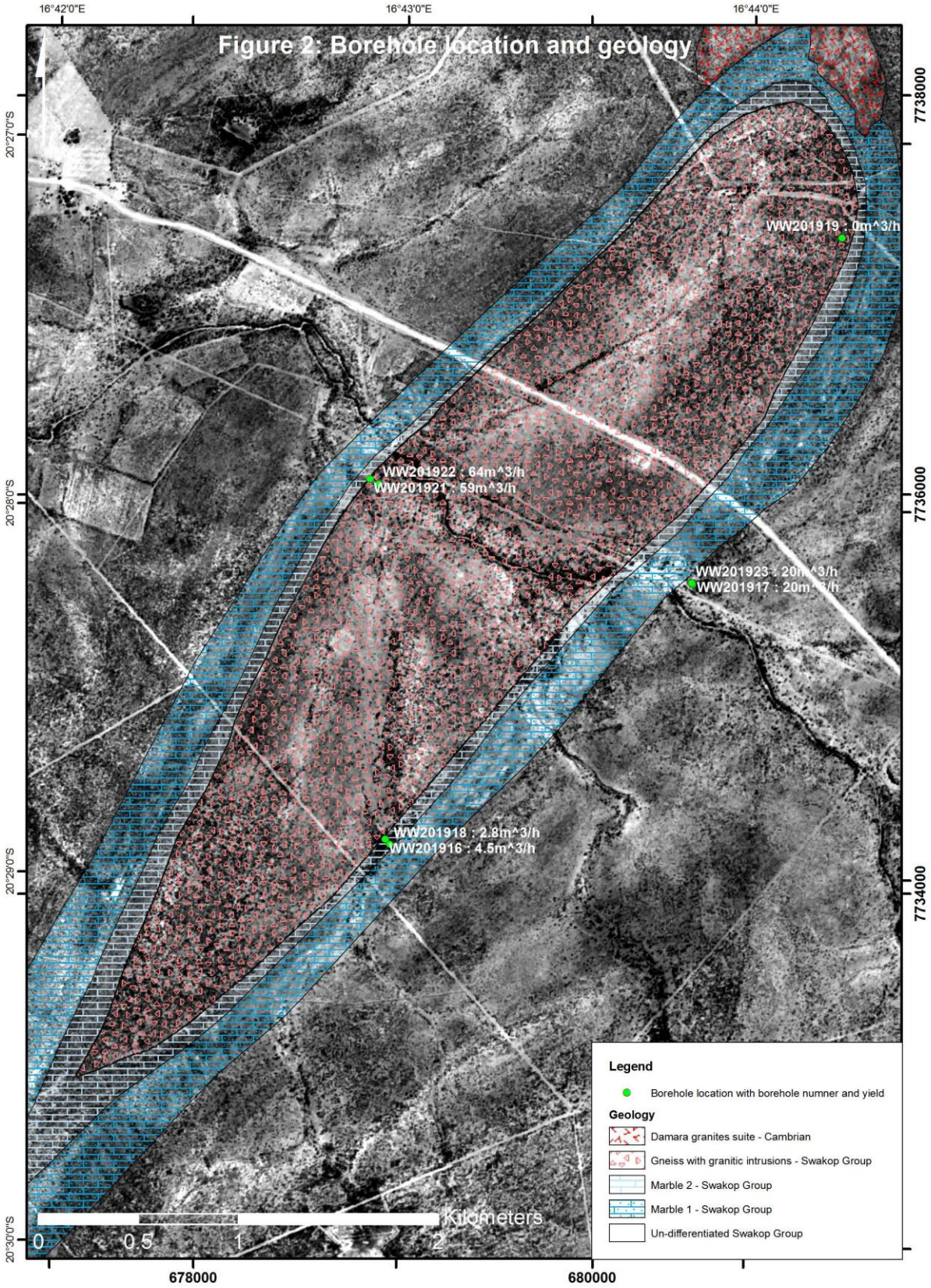

Figure 2-7: Positions of the boreholes assessed during the 2012 groundwater exploration (Namib Hydrosearch, 2012).

Table 2-9 below provides a summary of the water demand and yield of the boreholes:

Table 2-9: Water demand of the mines compared to the ability of the boreholes to provide water.

WATER DEMAND OF MINE	Phase 1			100 000 m3/year
	Phase 2			±150 000 m3/year
YIELD FROM BOREHOLES	Borehole 1 (WW201922)	64 m3/hr	360 m3/day	131 400 m3/year
	Borehole 2 (WW201923)	20 m3/hr		
	Borehole 3 (WW201918)	2.8 m3/hr	Yield is not included	

In determining the borehole yields, Namib Hydrosearch (2012) allowed for a conservative estimate of the abstraction of the farm owner (1.8 m3/hr) and they did not allow for natural recharge to the aquifer due to the unpredicatibility of rainfall.

The yield projected per year is therefore based on the assumption that no recharge will take place throughout the first phase of the project. Because of the poor yield from Borehole 3, it was not further investigated as a possible abstraction hole.

It was concluded that should the water demand of the mine not increase to 150 000 m3 at the end of the first phase of the project, the boreholes will yield enough water to solely supply water to the mine. Should demand however exceed this figure, additional sources of water will need to be investigated. Namib Hydrosearch (2012) however recommended that replenishment dams be built in the recharge zone to facilitate recharge to the aquifer, therefore making provision in case the demand is higher.

Following an application to the Ministry of Agriculture, Water and Forestry (MAWF), a water abstraction permit was granted for the extraction of maximum 300 000m3/year. As a condition, the permit requires that the water levels of each of the boreholes be recorded prior to switching the pumps on to determine the rest water level. These records in combination with the meter readings are to be submitted to an abstraction control officer.

In terms of the analysed constituents, the water quality of the boreholes is of Group B (Table 2-10), due to elevated total hardness (above 300 mg/l as CaCO3). The elevated hardness may cause scale deposition in the reticulation pipe work and storage tanks, and scaling when heated.

Table 2-10: Classification of water quality (from Water Quality Guidelines of Namibia, MAWF 1988).

CLASSIFICATION OF WATER QUALITY:	
GROUP A:	Water with an excellent quality, bacteriologically very safe.
GROUP B:	Water with good quality, bacteriologically still suitable for human consumption
GROUP C:	Water with low health risk. Water with a bacteriological risk for human consumption which requires immediate action for rectification
GROUP D:	Water with a higher health risk or water unsuitable for human consumption. Water which is bacteriologically unsuitable for human consumption.

2.7.3 Infrastructure corridor

The power line, pipeline and road will be constructed within the same corridor. These are discussed in the following bullets:

- ***Collection pipelines and reservoirs***

The sustainable water supply capacity from the two abstraction boreholes on the farm Doornlaagte is 21.7 m3/h. Water will be transport via a pipeline to an aboveground reservoir (capacity: 320 m3) and pump station at the eastern well in approximately 2 km distance (Figure 2-8) from the western well.

From the first pump station the pipeline runs in a south-western direction towards the B1. Gecko Graphite intends to bury the pipe underground up to the main road. Passing under the road is planned through a culvert nearby the T-junction with the mine's haulage road. It then traverses approximately 7 km to a second aboveground reservoir (capacity 320 m3) with booster pump station before turning onto the farm Okandjande.

This second pump station will be constructed within the old road reserve at the corner of the northern Osdam/Okanjande boundary line. From here the pipeline turns south towards the mine site, running along the farm boundary. The final reservoir has a capacity of 500 m3 and will be located above the processing plant to take advantage of the head for gravitating the water to the plant.

The material envisaged for the construction of the main pipeline will be 150 mm uPVC. For the first section, i.e. from the boreholes to where it passes under the B1, the pipe will be underground. From the road to the site it is planned to run above ground on pedastals within the de-proclaimed road reserve (Figure 2-9).

The 21.7 m3/h abstracted from the boreholes, will be pumped to a reservoir at the mine site.

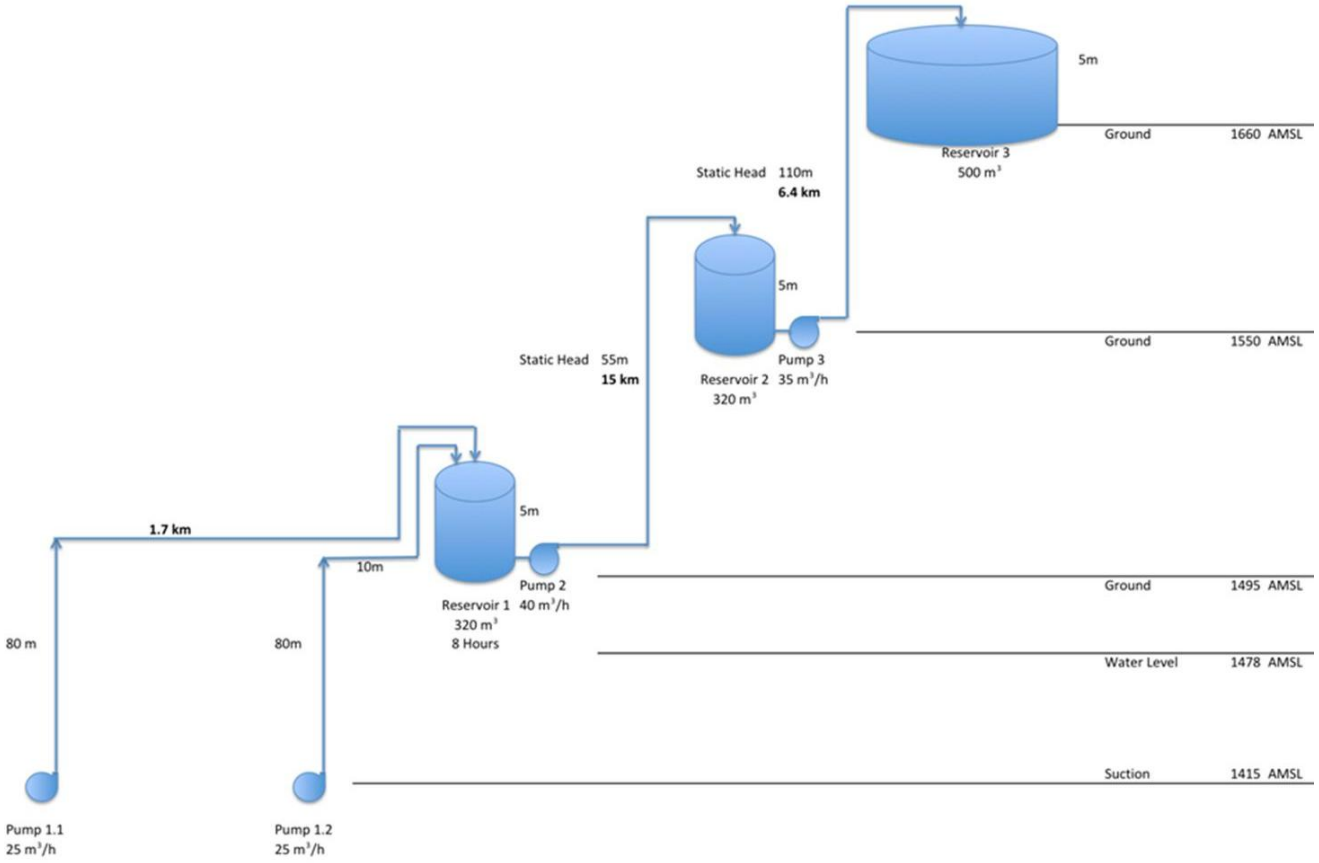

Figure 2-8: Water supply to the mine site.

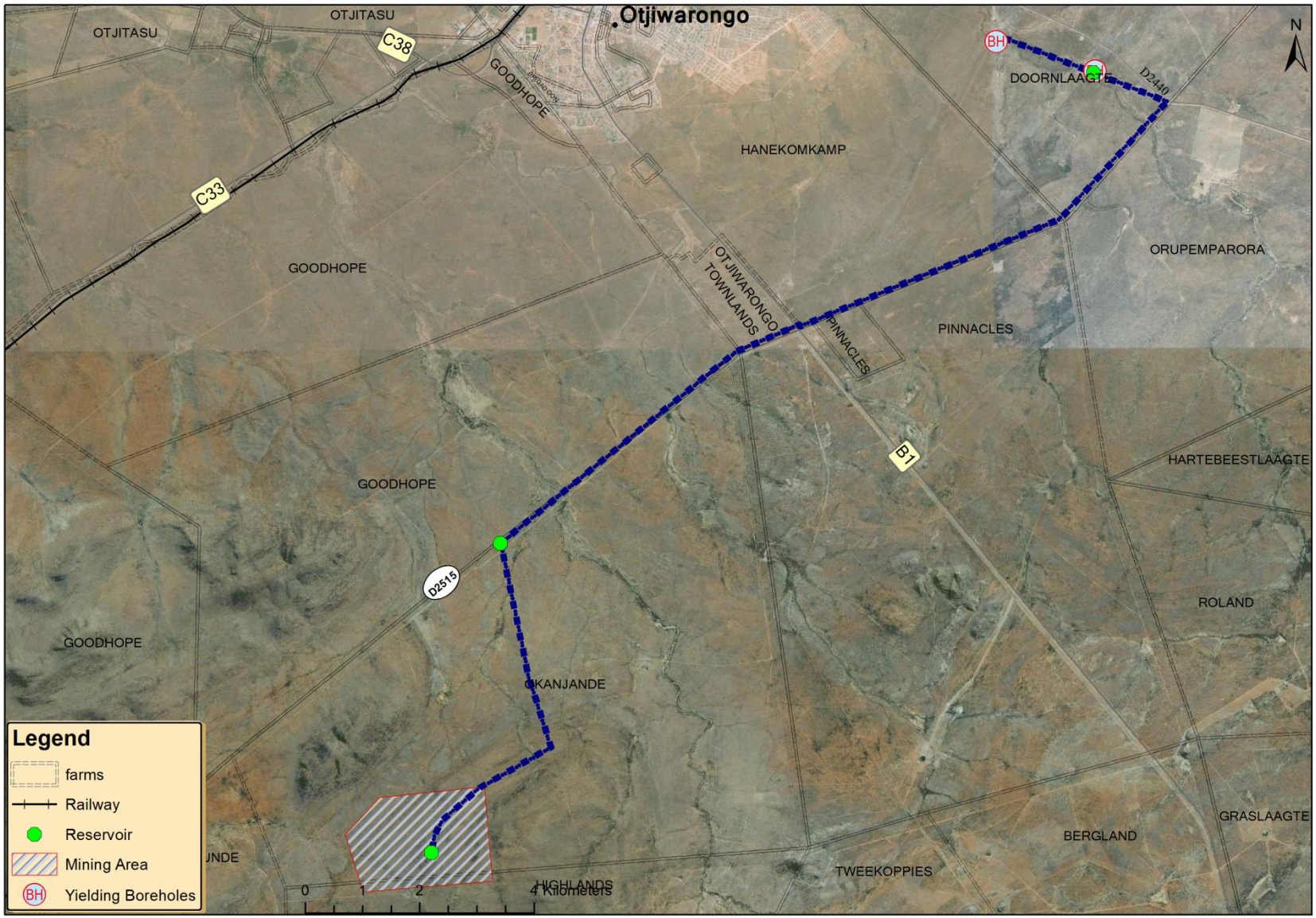

Figure 2-9: Position of the abstraction boreholes on farm Doornlaagte, the reservoirs and the pipeline route to the mine site.

- ***Transport***

Access is provided from Otjiwarongo / Windhoek to the mine site from the B1 main road (Figure 2-10). Approximately 5 km south-east of Otjiwarongo, the former district road D2515 turns westward from the B1. As this is now a de-proclaimed private road, maintained by the local farming community, a guard stationed at its entrance controls access and utilization. Negotiations between the owners of the road and Gecko Graphite are currently underway to try and establish the modus operandi for the future mine to fit into the current system.

From the old D2515, the access road and infrastructure corridor turns onto the Farm Osdam. It follows the boundary fence line with Okanjande for approximately 3 km before it cuts across the farm towards the mine site.

Rail transport is still investigated as a potential source of transport (of product during the operational phase) but due to its general unreliability and slow service it is anticipated that most equipment and materials used during will arrive per road on 10 and 15 ton superlinks (as well as bakkies and busses for small loads and labour). Two options for road access through Otjiwarongo to the railway station are nonetheless investigated (See insert on Figure 2-10).

During the construction phase most of the imported equipment will be shipped via Durban and Johannesburg to Namibia and it is likely that very little equipment will be shipped directly from overseas vendors to Walvis Bay. In contrast to this, most of the materials required for civil works e.g. rebar, will be transported from Walvis Bay. It is expected that approximately 20% of all traffic will come from Walvis Bay whereas 80% will come from Windhoek. An overview on the expected number of vehicles that will be used during the construction period is provided in Table 2-11 below:

Table 2-11: Number of operation vehicles that will be used during the construction period.

	CONSTRUCTION PERIOD:			
	FIRST 4 MONTHS	SECOND 6 MONTHS	THIRD 6 MONTHS	LAST 2 MONTHS
TRUCKS	30	120	20	2
BUS	1	3	1	1
BAKKIES	2	10	10	10
BAKKIE (MANAGEMENT)	2	5	5	5

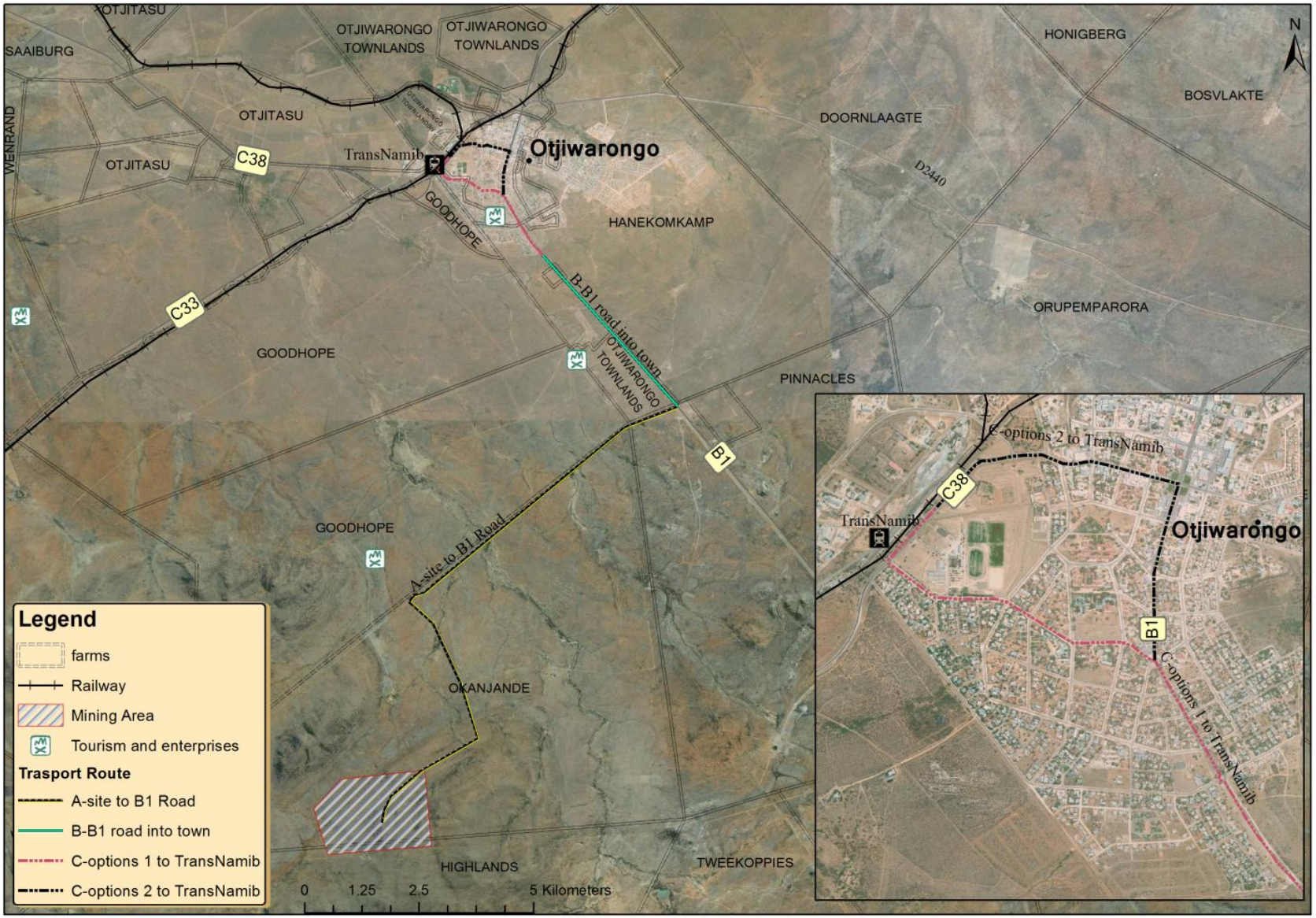

Figure 2-10: Road access between Otjiwarongo and the mine site, including alternative routes to the railway station.

During the operation phase workers will be housed in Otjiwarongo. Table 2-12 below gives an indication of the expected number of vehicles on the road per day/week.

Table 2-12: Expected transportation frequency during the operational phase of the mine.

OPERATION VEHICLES	TRANSPORTED COMMODITIES/MATERIALS	TRANSPORTATION FREQUENCY
Trucks (25 ton)	Reagents and consumables	3 trips per month
Tanker (32 ton)	Reagents and consumables	2 tankers per month
Trucks (30 ton)	Product dispatch	2 trips per day (4 trips both ways)
Busses	Workers	3 trips per day
Bakkies	Miscellaneous	11 trips per day
Tankers (30 ton)	Diesel delivery for drier and mobile fleet	2 trips per month

- ***Power supply***

Power will be supplied to the mine by means of a 66 kV line tapping off from the line that runs between Otjiwarongo and Okakarara. If it is adequate, the line will have a lower capacity of 33kV, with overall the same pole design features. At this stage of project design it is not certain whether the line will be 66 or 33 kV: this assessment is based on the 66 kV specifications provided by Gecko. A substation will be built at the T-off point from the existing line where the step-down transformer will be installed. The pump stations will be supplied with electricity through a 33kV return line with transformer substations at each pump installation.

From the boreholes, the power line follows the pipeline route to the mine site, constructed in the same servitude as the access road and pipeline and totalling a distance of 23 km. The 33 kV line will be owner operated which means that it will be installed and maintained by Gecko Graphite, not by NamPower. The line will probably be carried on single pole towers to the substation (APPENDIX B).

As illustrated with Table 2-13 below the average consumption expected on the project is 1,742.4 kW. Spare capacity of 10% or 174.2 kW is allowed for brining the maximum demand to 1,917 kW. . The maximum demand applied for from NamPower is 3 MW.

Table 2-13: Power demands expected during Phase 1 and 2 of operations.

TOTAL PLANT	KW
CRUSHER	213.2
MILLING	389.9
TAILINGS DISPOSAL	628.2
SCREENING & BAGGING	176.8
UTILITIES	333.8
SPARE CAPACITY 10%	174.2
TOTAL	1 916.6
* 1 MW = 1000 kW	

2.7.4 Sewerage system

A trickling filter sewage treatment plant will be constructed close to the plant to treat sewage and moderately polluted effluents. The envisaged sewage treatment system is environmentally friendly and can effectively treat effluent from 300 people (maximum number of workers envisaged during construction) so that the water can be reused.

During the first stages of the treatment of wastewater, a screen is used to clean any non-degradable material. In a two-chamber septic tank, aerobic and anaerobic digestion takes place (Figure 2-11). The effluent is then pumped onto the fixed film trickling filter with a submersible pump. In the trickling filter the biological treatment takes place to remove harmful organics. The final solids separation follows in a settler with subsequent disinfection of the final effluent with chlorine (Aqua Services and Engineering, 2001).

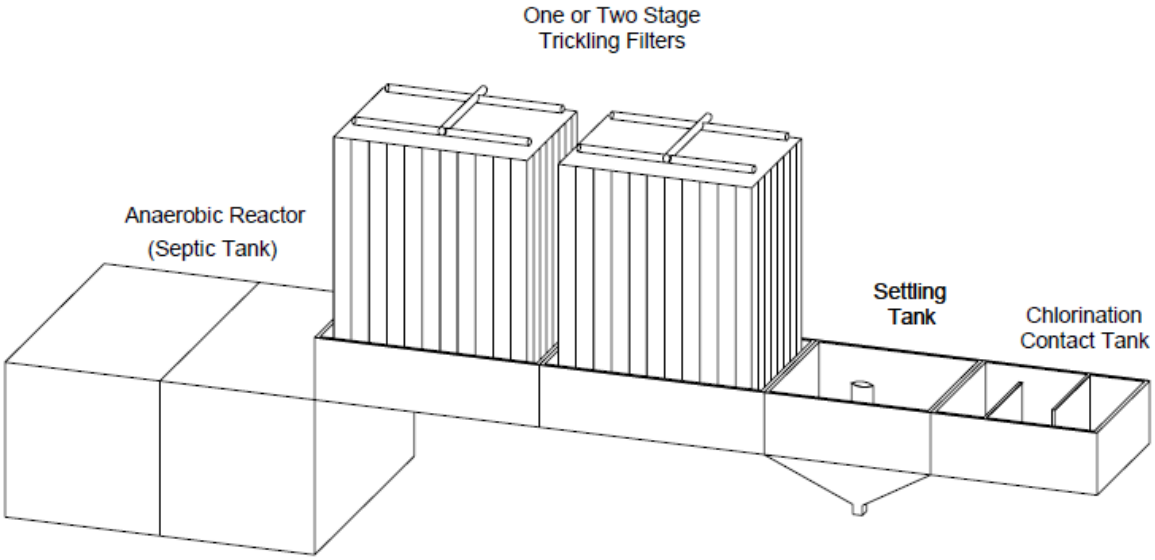

Figure 2-11: Envisaged trickling filter sewage treatment plant ((Aqua Services and Engineering, 2001)).

2.7.5 Solid waste disposal

Domestic waste will be stored in waste skips and removed on a weekly basis by a local contractor for disposal in the Otjiwarongo waste disposal site.

Industrial waste will be removed in a similar fashion except for all old oil which will be collected in tanks for future use in blasting. Oil traps will be installed at the workshops.

Hazardous waste will be disposed of in the following manners Table 2-14:

Table 2-14: Different sources of hazardous waste and intended modes of disposal.

HAZARDOUS WASTE	SOURCE	PROPOSED MODE OF DISPOSAL
Radioactive sources	Densitometers, level gauges and the XRF instrument	To be disposed offsite through a licensed hazardous waste disposal agent.
Hydrocarbon contaminated materials	Used oil, grease, oil rags, paint tins, solvent cleaner rags	Oil and grease will be recovered from equipment and machinery and stored in drums and stored in a bunded area before being sold offsite for recycling. Any fuel spills will be soaked up onto a suitable absorbent and disposed of together with oils and grease. Any fuel/oil contaminated soil will be disposed in a plastic drum/bag and taken to a

HAZARDOUS WASTE	SOURCE	PROPOSED MODE OF DISPOSAL
		bioremediation facility.
Halogenated solvents	Any organic chemical containing F, Cl, Br or I. E.g. Chloroform, carbon tetrachloride, methylene chloride, trichloroethylene	Collected in plastic drums and disposed off site through a licensed hazardous waste disposal agent.
Fluorescent tubes		Crushed and collected in drums until sufficient quantities have been collected, to be disposed offsite through a licensed hazardous waste disposal agent.
Acids	H2SO4	Neutralized with a base and/or recycled.
Bases	NaOH	Neutralized and/or recycled.
Used pesticide containers	Spraying for mosquitoes, insects, etc.	Collected in plastic drums and disposed offsite through a licensed hazardous waste disposal agent.
Laboratory waste	Diluted acid and bases, samples prepared for XRF using the fusion method and powder pallet methods contains lithium borate and wax.	Acid and base mixtures will be collected in plastic drums, to be disposed of offsite through a licensed hazardous waste disposal agent. Samples will be disposed of with the plant tailings.
Fuel spills		Any fuel spills will be soaked up onto a suitable absorbent and disposed of together with oils and grease. Any fuel/oil contaminated soil will be disposed in a plastic drum/bag and taken to a bioremediation facility.
Batteries		Used batteries will be stored in plastic drums, to be disposed off site through a licensed hazardous waste disposal agent.

HAZARDOUS WASTE	SOURCE	PROPOSED MODE OF DISPOSAL
Medical waste from on-site clinic		To be incinerated at the Otjiwarongo hospital.
Reagent containers/drums/bags		If possible these will be cleaned and/or re-used or sold. If not possible to clean 100%, it will be damaged to prevent re-use and disposed of by the waste disposal agent.

2.7.6 Employment

- ***Workforce***

During the construction phase of 14 to 18 months 300 to 400 people will be employed in the peak period. This number decreases significantly during operations to 73 people to manage and operate the plant, excluding the mining personnel as this it anticipated to be contracted out (Table 2-15). The semi-skilled and as many skilled personnel as possible will be sourced locally; the remainder will be recruited from elsewhere. It has been indicated that approximately N$ 17 252 285.00 will be spent on salaries annually.

The above matter underwent detailed investigation during the socio-economic specialist study (Saayman, 2014).

Table 2-15: Expected distribution of skills for employment during operations of the mine.

	OVERHEADS	PROCESSING	TOTAL
SEMI-SKILLED	11	24	35
SKILLED	7	24	31
MANAGEMENT	6	1	7
TOTAL	24	49	73

- ***Operating hours***

The operating hours at the mine and processing plant will be as follows, resulting in the indicated shift schedules (Table 2-16):

Table 2-16: Operating hours of the mine and processing plant, and the associated shifts required.

	OPERATING HOURS	SHIFTS
CONSTRUCTION	14-18 months	12 hour shifts, 6 days per week
MINING	24 hours/day 7 days/week	3 x 8 hour shift, 7 days per week
PROCESSING		
• Crushing, Milling, flotation, Concentrate dewatering, Tailings Disposal, Utilities	24 hours/day 5 days/week	3 x 8 hour shifts, 5 days per week
• Weighing, bagging, Product Despatch	8 hours/day, 5 days/week	1 x 8 hour shift (daytime), 5 days per week

- ***Accommodation***

During normal operations at the mine the workers will be accommodated in Otjiwarongo and will be bussed to and from site. Senior personnel will travel by smaller mine vehicles (e.g. bakkies and double cabs). During the construction phase of the project two alternatives are considered regarding accommodation:

- ❖ Option 1 is to accommodate workers in Otjiwarongo. This option depends on the availability of erven and the ability of services to accommodate the additional pressure.
- ❖ Option 2 is to accommodate workers in a camp site at the mine. This option reduces the pressure put on the services in Otjiwarongo as well as the pressure on the private road. However, it poses social concerns to the neighbouring farmers.

The two alternatives are further investigated in Chapter 3 of this report.

- ***Transportation***

Should construction workers be accommodated in Otjiwarongo, transportation to and from the mine site will be provided by means of busses. This is in line with requests from the neighbouring farm owners that workers should not be allowed to use private vehicles to arrive at the mine site.

- ***Security***

A standard 2.4 m weld mesh security fence will be erected around the plant.

3 Project Alternatives

Alternatives are defined as: "different means of meeting the general purpose and requirements of the activity" (Environmental Management Act (2007) of Namibia (and its regulations (2012))). Therefore, the purpose of this chapter is to highlight the different ways in which the project can be undertaken and to identify the alternative that will be the most practical but least damaging to the environment.

Once the alternatives have been established, these are examined by asking the following three questions:

1. What alternatives are technically and economically feasible?
2. What are the environmental effects associated with the feasible alternatives?
3. What is the rationale for selecting the preferred alternative?

The alternatives considered for this project are discussed in the subsequent paragraphs.

3.1 Type of activity to be undertaken

3.1.1 The 'no-go' alternative

This alternative predicts the future scenario which would exist in the absence of any project. It is represented by the status quo, as described in the baseline description (Chapter 5). Should the proposed project not receive Environmental Clearance from the DEA, the 'no-go' alternative will prevail.

The current land use in the area consists primarily of livestock farming and, to a lesser degree, hunting tourism operations. The 'no-go' alternative will result in the continuation of these land use activities. Agriculture provides direct benefits to those who engage in it (farmers receive payments for selling their livestock) whereas the benefits of mining are more indirect relating to:

- Generating government revenues through taxes and royalties,
- Increased employment opportunities for local people,
- Greater development and associated socio-economic development of the area.

The current land use activities are marginally economically viable due to the intensive bush encroachment and the scarcity of groundwater in the area. Therefore, it cannot provide the level of short-term and long-term economic growth to the area that this project would offer.

If the Project was not to proceed, the additional economic activity, skills development and availability of jobs would not be created. In addition, the Okanjande graphite reserve would remain unutilised.

In considering the proposal for this project, the 'no-go' option is not considered the preferred alternative.

3.2 Location Alternatives

3.2.1 Pit location

The location of the pit is confined to the deposit boundaries and therefore no viable alternative exists to the mine's location.

3.2.2 TSF location

Because of the potential risks associated with the operation of the TSF, the location of the facility is of crucial importance. Two options were considered namely 1) the originally proposed location of the TSF proposed during the 1993 studies and 2) a location approximately 1000m north-west of the processing plant (Figure 3-1).

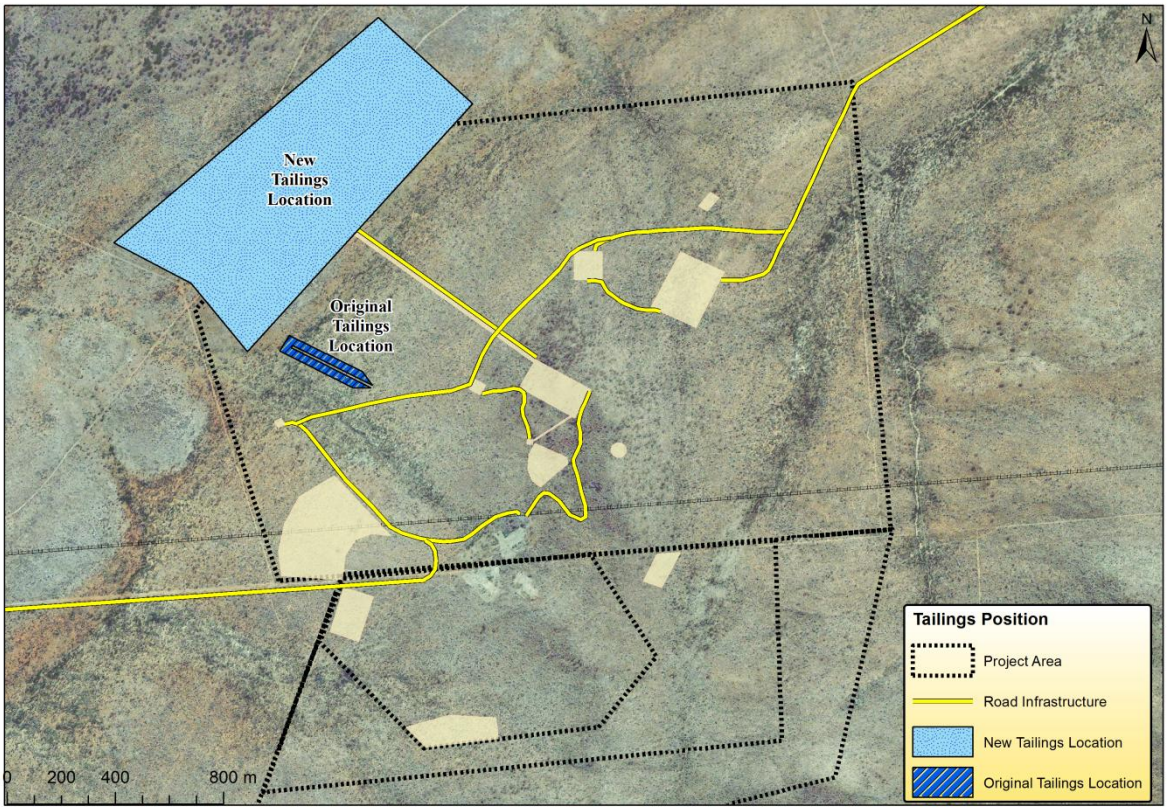

Figure 3-1: Potential locations of the TSF.

The two locations are assessed based on the risk factors provided in Table 3-1 below:

Table 3-1: Comparative analysis on risks (without mitigation) between the two locations considered for the TSF.

RISK FACTOR	ORIGINALLY PROPOSED LOCATION DURING THE 1992 EIA	NEW LOCATION NORTH-WEST OF PROCESSING PLANT
STEEP SLOPES (TOPOGRAPHY)	Site is located in a drainage line but the terrain is relatively flat.	Site is located on a large marble outcrop with a low relief.
SURFACE WATER SOURCES	It is located in a drainage line flowing south-east to north-west across the project area. The drainage line is situated on an underground contact zone between the Nosib Group quartzite and the Swakop Group marble. The drainage line forms part of the catchment area of the Ugab River.	The new location is situated on slightly elevated ground with drainage lines to the south, north and west of the site. These drainage lines are not intersected/covered by the proposed TSF.
GROUNDWATER FLOW	Because of the fault of the Swakop Group and Nosib Group contact zone, groundwater is present due to the higher permeability within this fracture. This could potentially lead to groundwater pollution.	Groundwater flows away from the location in an eastern and western direction. The flow rate through impervious marble / calc-silicate is likely to be very low.
ACID – BASE ABSORPTION POTENTIAL OF THE UNDERLYING ROCKS	The Nosib Group quartzite and ore body hosts sulphides and therefore have a potential for acid generation.	The marble and calc-silicate rocks have an acid neutralizing capacity.
PERMEABILITY OF UNDER LYING ROCKS	The site spans across the contact zone between the Swakop Group and Nosib Group which is faulted and has higher permeability.	The site is located on marble and calc-silicate rocks. The rocks have low permeability and are not affected by faulting. This was confirmed by geophysical profiling and drilling.
PRESENCE OF THE MOST CONSISTENT AND STRONGEST WIND	Prevailing east-west wind with less frequent winds from the north. The site is orientated south-east to north-west, with the longer side of the TSF facing the prevailing easterly winds.	Prevailing east-west wind with less frequent winds from the north. The site is orientated south-east – north-west with the hill to the north shielding the TSF from the northerly winds, with the narrow side facing the easterly winds. This lowers the

RISK FACTOR	ORIGINALLY PROPOSED LOCATION DURING THE 1992 EIA	NEW LOCATION NORTH-WEST OF PROCESSING PLANT
		effect of wind erosion across the surface of the TSF.
DISTANCE TO PROCESSING PLANT	600m west of processing plant	1000m north-west of processing plant

From the work conducted to date, especially from the data received from the climate, hydro-geological and ABA studies performed for the project, the most favourable site for the construction of the TSF is the new location situated to the north-west of the envisaged plant on the marble and calc-silicate rocks. This site avoids the contact zone of the carbonate rocks with the surrounding Nossib quartzites as well as any possible groundwater intake structures such as faults and surface drainage channels. The tailings area is restricted to the dense Swakop Group marble and calc-silicate unit with proven low permeability. An additional advantage of this location is the neutralization capabilities of the lithologies underlying this site. This should ensure long-term and safe storage of the tailings.

The possibility of expanding the TSF further to the west was also investigated. Since this area represents a continuation of the marble and calc-silicate lithologies, an expansion in this direction appears to represent a low risk. This was not assessed in detail as part of this EIA.

3.2.3 Camp Location (construction camp)

During operations, workers will be accommodated in Otjiwarongo. However, during the peak of the construction phase approximately 300 people will be employed that will require housing. Since many of these workers may not necessarily be locals, two alternatives were therefore considered for the camp location:

- Off site which implies that a construction camp site will be created within the Otjiwarongo townlands, making use of the town's services and transporting construction workers to site on a daily basis.
- On site which implies that a construction camp site will be established at the mine site.

Various risk factors were considered in determining the preferred alternative. These are listed below for each of the two options (Table 3-2).

Table 3-2: Comparative analysis on risks (without mitigation) between off site and on site accommodation of workforce.

RISK FACTOR	OFF SITE ACCOMMODATION IN OTJIWARONGO	ON SITE ACCOMMODATION
TRAFFIC IMPACT / ROAD DAMAGE	This will result in increased traffic on the private road between the main road and the mine site, as well as more traffic in town as the employees will have to be transported.	Daily transport of employees will not be needed, thus the impact may be less on the private road and the carbon footprint smaller.
LOCAL ECONOMIC IMPACT	Transport of employees could benefit a local subcontractor. Local spending will increase during the construction phase.	Spending might take place elsewhere. Food for the workers can be sourced in Otjiwarongo.
WATER CONSUMPTION	Increased pressure on available services and infrastructure in town.	Water infrastructure will have to be established and provided by the client.
WASTE DISPOSAL	Services and infrastructure available in town.	No available services on-site. Infrastructure and related services to be established or waste to be trucked to the municipal dump site.
SANITATION	The available infrastructure and services are already operating at full capacity.	No available services on-site. Infrastructure and related service of the infrastructure to be established by project developer.
POACHING	Risk is lower if accommodated in town.	Risk increases if workers are staying on site especially during the site establishment phase when control over the movement of workers may be difficult.
CONSTRUCTION OF HOUSING	The availability of housing is a big challenge to the Otjiwarongo Municipality. The provision of housing and related services will have a significant impact, especially since housing is limited in town and new erven might not be available by the time	Temporary housing will have to be constructed and removed once the construction phase is finalized. The client will have to identify an area with the least environmental impact and provide necessary services.

RISK FACTOR	OFF SITE ACCOMMODATION IN OTJIWARONGO	ON SITE ACCOMMODATION
	construction commences.	

Both of the considered options present some challenges. On-site accommodation could constitute an option subject to the provision of adequate infrastructure and environmental control by the project developers. However, surrounding land users have voiced their concern and objection towards uncontrolled movement (which is associated with on-site accommodation) of people on the farm and on the access road. The matter would represent one aspect for regular environmental reporting.

Although accommodating the construction team in Otjwarongo would put additional pressure on the existing services, it remains the preferred alternative. It is therefore suggested that no construction workers be housed on site and that the proponent come into agreement with the local municipal authority on a suitable town lands area preferably already disturbed. Should no such area be available, a suitable area is to be negotiated with the municipality which will consider neighbouring land users and land owners.

3.3 Alternative technologies and methods

3.3.1 Alternative mining methods

Graphite is mined from both open pit and underground mining operations (Feytis, 2010). Underground mining results in generally lower dust emissions from the operations. However, in this instance, the Okanjande deposit is located close to the surface which means that it can be mined with simple open pit methods with a very low waste-to-ore ratio. The deposit also extends more in its width than it does in depth and therefore production can be expanded by moving laterally rather than going deeper, which is also much more expensive. For these reasons the open pit mining method is deemed the most optimal extraction method for the Okanjande deposit.

In terms of the mining rate, two alternatives were also investigated (Table 3-3):

- Option 1: The mine will operate 52 weeks per year, five days per week, and eight hours per day. This will require drilling and blasting to be done 2-4 times a year to ensure that enough material is available to be hauled into the crusher or onto the plant's ROM stockpile (envisaged to be 48 hours capacity).
- Option 2: The whole year's required tonnage is blasted at the beginning of the year and the material hauled to the ROM stockpile. It will require mining to take place for 24 hours, 7 days a week for a period of up to four months. During the first phase mining will take place twice a year, increasing to four times a year

during the second phase. This means that there will be a lot of activity in the mine for a short period per year after which nothing will happen in the pit. Since Option 2 is based on the principle of contract mining, no own mining equipment will have to be purchased and no labour will be required by the proponent for the mining.

Table 3-3: Comparative analysis of the two mining rate options.

RISK FACTOR	OPTION 1	OPTION 2
FREQUENCY OF DRILLING AND BLASTING	Throughout the mining operations	For the 10 000 tpa product scenario, twice a year, for the 20 000 tpa scenario 4 times a year
SIZE OF THE ROM STOCKPILE	Two ore stockpiles, one containing weathered ore and the other fresh ore. It would cover approximately 6,000 m2.	The footprint of this ROM stockpile will be 105 X 80 meter, 23 meter high, or 8,363 m2.
DUST CREATION	Dustfall is expected to be less intense but long term.	Dustfall is expected to be more intense but short term.
FINANCIAL COST	Small mining operation which still require skill and specialized equipment. Underutilization of specialized equipment and workforce constitutes a high economic expense. For the 20,000 tpa graphite option @ N$827.10 per ton graphite. For the 10,000 tpa scenario the cost will be N$1,206.91 per ton graphite produced.	Specialized equipment and skilled personnel will only be onsite during the mining operations (4 months). Thereafter they will no longer be an unnecessary expense. Cost is N$688.00 per ton of graphite produced

The costs associated with running mining operations (including the personnel and equipment) for 8 hours per day, 5 days per week is not deemed economical for a mining operation of this small size. Therefore, to ensure that employees and equipment are optimally utilized, mining activities will ensue for a period of one to four months.

The intensity of the associated impacts (i.e. dust, noise, movement of vehicles on the private road) is likely to be more severe during this period but will be short term. Once the required tonnages have been mined and stockpiled, normal operations will continue whilst all activities are ceased at the mine pit. It is expected that for the first phase of the project (10

000 tpa) these mining periods will occur twice a year, and for the second phase (20 000) four times per year or once every quarter.

In undertaking the mining operations in this manner, Gecko will not be required to purchase the civils equipment (e.g. additional ADTs and bulldozers) since the mining component can be outsourced for the specific mining period. The costs associated with undertaking the mining project can therefore significantly be reduced by undertaking the activities according to option 2 which makes it the preferred alternative for mining.

3.3.2 Alternative ore processing methods

Although other methods of graphite beneficiation do exist, the most widely used is the flotation method. The process is particularly useful when dealing with flake graphite as it does not lead to diminished flake sizes, thereby reducing the value of the product.

For this reason, the flotation method has been selected as the best alternative for processing the ore.

3.4 Alternative TSF design options

Given the location of the mine and the TSF as well as the quantities of tailings to be disposed of, there are three major criteria that govern the choice of disposal method:

- The necessity to conserve water
- The necessity to minimize water pollution
- The requirement to keep costs as low as possible while meeting the other constraints

Based on these criteria two design options were considered for the TSF namely:

- A dry TSF that would have tailing that contain less than 20% (design target: 15.3%) moisture;
- A dewatered, wet TSF disposal system that contains 79.12 m3/h of water (48% solids) after being 50% dewatered using a hydrocyclone. Up to 79.1% of the water can be recovered with an anticipated water loss of 12.89m3/hr (Table 3-4).

Table 3-4: Water usage associated with the two options (from Hydrosearch, 2014).

OPTION	WATER DISPOSAL (M3/H)	50% RECOVERY BY DECANT SYSTEM (M3/H)	5% RECOVERY BY DRAINS (M3/H)	WATER LOSS (M3/H)	BALANCE IN TSF (M3/H)	REMARKS
DRY	12.89	-	-	12.89	-	Ideal
DEWATERED WET (48% SOLIDS)	79.12	62.59	3.65	12.89	0.01	best case (79.1% recovered)

The two options are discussed in more detail in the following paragraphs:

3.4.1 Dry tailings disposal

- ***Description***

Dry tailings deposition methods require that the material be dewatered before it is sent to the tailings dump. According to the detailed trade-off study (ADP Projects, 2014) the water content must be sufficiently low so that:

- ❖ the material can be easily transported and discharged onto the dump without forming large lumps or sticking to the conveyors or other transport equipment, and
- ❖ the tailings will remain unsaturated after placement on the dump, even after the application of load from 20m or 30m thickness of superimposed tailings, so that the slope stability will not be adversely affected by development of pore pressures in the deposit.

Tailings produced from a cyclone with its overflow reporting into a high density thickener combined with the thickener underflow and resulting in a slurry containing 46.53% solids at a rate of 36.28 tph solids, is dewatered in the plant with a continuous belt filter. The dewatering filter takes the filter cake down to 15% moisture. Based on the results of laboratory tests undertaken on this project the moisture content of the tailings sent to the dump should not exceed 20%. Above 20.27% moisture content the dewatered tailings stockpile becomes unstable (Gecko, 2014).

- ***Transport of tailings***

In order to transport the tailings to the TSF, two modes of transport were considered by (ADP Projects, 2014):

	DESCRIPTION
ROAD TRANSPORT:	The tailings is stockpiled at the plant from where it is loaded via a dedicated Front End Loader (FEL) onto a ADT transporting the dewatered tailings to two 'dry' tailings stockpiles. The stockpiles will be formed with a FEL or Bulldozer on prepared areas, equipped with windrows, a tow, drainage trenches and access roads. Assuming the use of 30 ton capacity trucks 2.5 truck loads per hour would be needed. For the distance involved (approximately 2,000 m round trip) a round trip time would be 16 minutes. Two trucks would possibly be necessary to achieve a realistic cycle.
BELT CONVEYOR SYSTEM:	The dewatered tailings material is transferred via an overland belt conveyor with 30kW installed power and 450mm wide of 950m length. This conveyor is covered with a 'doghouse' to prevent wind losses and excessive water retention during rainstorms. At the two tailings stockpiles, operators will move the stacking conveyor discharge points along the allocated stockpile area from where it will be spread with vehicle bulldozer. The stockpile will use windrows to form the stockpiles discharge profile and then be spread to a toe, formed with compacted earth walls. The stockpiles and the stockpile area will be manned by a dedicated labour force and a FEL/Bulldozer has been allowed for. The mobile conveyors (the telescopic and spreading conveyors) will be positioned with the FEL/Bulldozer.

- ***Lay out***

The following characteristics apply to the dry disposal alternative:

DRY TAILINGS DISPOSAL	
TAILINGS MOISTURE CONTENT (TRUCK OFF-LOAD)	<25%
DESIGN	Form of a trapezium tapering from a narrow northeastern top (455m) to a wider southwestern bottom (590m).
DESIGN FINAL FOOTPRINT	630,360 m²
DESIGN FINAL HEIGHT	25 -28m
ANGLE OF REPOSE	40° to the horizontal

DRY TAILINGS DISPOSAL	
DRY DENSITY OF TAILINGS	1.35 t/m³
VOLUME PER YEAR	300,000 m³
2 YEARS CAPACITY	750,000 m³
2 YEAR "DUMP" LAYOUT	70,750 m² (283m x 250m)
TOE WALL	250 m

Gecko (2014) provides the following details about the construction of the dry tailings facility:

"*For dry tailings disposal the top surface is placed horizontal for ease of control of setting out and operation of the dumping process. Initially the side slopes, formed during discharging of the tailings will be at the angle of repose of the material, approximately 40° to the horizontal. The edge of the dump as formed when the tailings are dumped will be marked by a windrow. The permanent outer faces must be finished to a slope of 1m vertical to 3.75m horizontal by dozing material downwards from the top edge of the dump in order to achieve long term stability. A permanent toe wall constructed of earth-fill defines the final toe. The distance of the windrow from the toe wall will vary to suit the height of the dump, at a height of 23m it will be 59m from the toe wall and 27.5 m from the discharge point.*"

- ***Return water***

Storm runoff will be intercepted by an effluent trench around the perimeter of the dump. This will lead to a return water dam (RWD) outside the south-eastern side of the dump.

RETURN WATER DAM	
STORM EVENT COVERAGE	1 in 100 year 24-hour rainfall
CAPACITY FOR TAILINGS AREA	9,000m3 (Initially 4,500m3)
MANAGEMENT	Allow for silt and suspended solids to settle out first before the clean water overflows a weir into the pumping chamber. The settling area must also be divided into two sections to allow for the one section to be mechanically cleaned while the other is in operation. Any water reaching the RWD can be pumped out and returned to the plant for reuse.
SEEPAGE CONTROL	Located on marble and calc-silicate bed. To prevent seepage into the ground the RWD will be lined with a double

RETURN WATER DAM	
	layer impervious lining with a plastic geomembrane underlain by a geotextile and strip drains, to detect and remove any seepage through the primary lining, and a secondary lining of the marble bed. Any water reaching the seepage detection system will flow to a concrete lined trench and sump outside the downstream wall and evaporated or pumped back into the dam.
RETURN WATER PIPELINE AND PUMPING SYSTEM	
STORM EVENT COVERAGE	Should be sufficient to cover a 1-in-5 year storm event

- ***Seepage and pollution control***

To prevent seepage from penetrating into the ground the TSF will be protected by providing a controlled preferential drainage path, which is underlain by an impervious barrier as discussed in the table above. After the topsoil covering the marble bed is levelled and prepared, a system of prefabricated strip drains is to be laid within the top soil above the marble, at centres varying from 20m to 5m depending on the location. A cover of clean river sand assists seepage to enter the drains and protects the strip drains. The strip drains will exit into the perimeter effluent trench, thus any water collected will be routed to the RWD. Provision will be made to line the base of the effluent trench with a dished concrete drain (Gecko, 2014).

- ***Conclusion***

Dry tailings disposal has advantages and disadvantages. These are discussed below:

ADVANTAGES	DISADVANTAGES
Usually considered in areas with water scarcity as is the case with the Okanjande deposit. Dry tailings disposal can recover up to 85% of water, as opposed to 50% (typical) achieved by wet tailings disposal.	Material needs to be dewatered before it is transported to the stockpile site. This introduces additional processing steps and equipment at the plant, with associated costs that can be high.
Stable stockpiles can be built	Other extra attention and costs are incurred in transporting the dewatered tailings to the dump, whether by truck or conveyor and for forming the deposit
Seepages into groundwater can be kept low	The dry tailings disposal is prone to produce more

ADVANTAGES	DISADVANTAGES
without building leak-proof lined TSF.	dust and bears a greater risk of wind erosion.

3.4.2 Wet tailings

- ***Description***

Wet tailings, per definition, is tailings with a high water content ranging from a watery pulp to a dewatered slurry (30%, 40% and a maximum of 50%). From an economical point of view, wet tailings deposition is preferred because the tailings can be pumped directly to the TSF, avoiding dewatering processes and equipment. Therefore, the deposition procedures require only limited expenditure on equipment or supervision.

For the Okanjande project only a dewatered wet tailings disposal method with 48% solids is considered, primarily due to the unacceptable water losses that result from the fully wet method (in the order of 40% to 50% of the water sent to the TSF) and increased risk of seepage and contamination associated with such practice (9.1% solids).

To partially dewater the slurry, the produced tailings is passed through a dewatering cyclone to produce an underflow with 50% solids. The cyclone overflow is routed to a thickener to settle out any suspended solids from it. The settled solids from the thickener contain 46.3% solids (53.7% moisture) and are pumped as dewatered tailings to the disposal site. The clear water from the thickener overflow will be reused in the plant. The supernatant water at the tailings dump will be pumped back to the plant for reuse and it is anticipated that by using a floating pumping system the water recovery from the dump will be in excess of 60%.

- ***Lay out/design***

The following characteristics apply to the wet disposal alternative:

WET TAILINGS DISPOSAL	
TAILINGS MOISTURE CONTENT (WITH CYCLONE)	51.15%
DESIGN FINAL FOOTPRINT	630,360 m2
DESIGN FINAL HEIGHT	–26 m
PERIMETER WALLS	20m width bottom; 10 m width top x 2m high
VOLUME PER YEAR	150,000 m³ - 300,000 m³
ANNUAL RISE RATE	2 m & beach angle of 1:100

WET TAILINGS DISPOSAL	
CELL CAPACITY	300,000 m³ per annum
CELL SIZE	283,770 m² (543 m x 523 m)
TYPE OF DISCHARGE	Floating decant pumps
CAPACITY OF CEL1, 2 & 3 COMBINED	16.84 million m³ (22.7 million tons)

To construct the wet disposal system, starter walls (constructed with compacted earth) will be erected around the footprint of the tailings "cell" (Figure 3-2). These starter walls will be 20 m wide at surface and 10 m wide on top with a beach area sloping to the centre of the cell at 1m in 100 m (Gecko, 2014). The thickened tailings material is then deposited in the dam via an open-ended slurry pipe. The pipe is moved around the perimeter wall so that the dam fill is distributed along the perimeter wall and fluid slurry runs down to the centre of the dam. Decanted water is collected from the centre of the cell via a floating pumping station. The TSF and perimeter trenches are underlined by an impervious HDPE liner that collects seepages and rainwater run-off (ADP Projects, 2014).

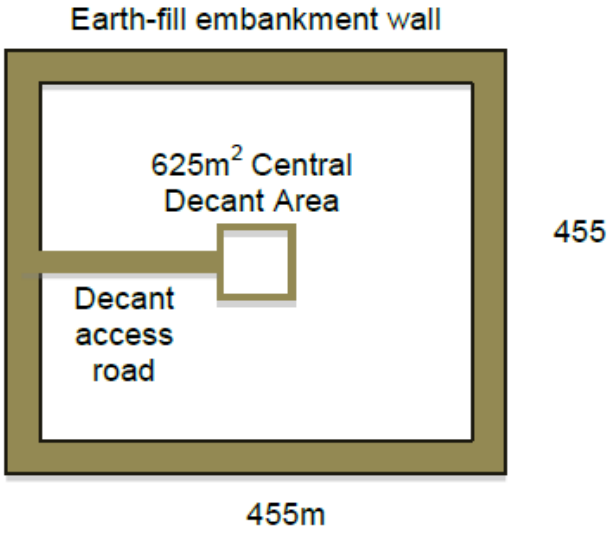

Figure 3-2: Typical layout of a cell. Three of these cells are envisaged.

The decant access road will be 6m wide and will be raised with the perimeter walls. This type of infrastructure is typical of the paddock discharge type system.

- ***Surface water management***

Storm runoff will be intercepted by an effluent trench around the perimeter of the dump's footprint. The water is directed to a return water dam (RWD) outside the south-eastern side of the dump.

RETURN WATER DAM	
STORM EVENT COVERAGE	The internal catchment area of the 1st cell is 220,266 m2. The 1-in-100 year rainfall over a 24-hour period on this area = 35,242m3. The external catchment area is 63,504 m2.

RETURN WATER DAM	
	The 1-in-5 year precipitation over a 24 hour period on the internal catchment area = 14,317 m3. The 1-in-5 year rainfall over a 24-hour period over the external catchment area is 4,128 m3.
VOLUME REMAINING IN CELL (AFTER BEING FILLED WITH TAILINGS)	2,139,857m3
MANAGEMENT	A RWD with a capacity of 4,500m3 and designed with a solids dropout section and an overflow weir for the clean water into the pumping chamber will be constructed. The water will be pumped back to the processing plant and access water will be diverted to the storm water system. The pumping system will be designed to pump out the 1-in-5 year rainfall collected over a 24-hour period within 6 days, i.e. at 29m3/h.
SEEPAGE CONTROL	Strip drains will be layered and covered with 150mm of clean river sand. The tailings will be deposited on top of the river sand layer. Seepage will be collected via the strip drains to the perimeter trenches and gravitated to the RWD from where it will pumped back to the processing plant for reuse.
RETURN WATER PIPELINE AND PUMPING SYSTEM	
STORM EVENT COVERAGE	1-in-5 year storm event falling over the active dumping area needs to be pumped out within 6 days. Water in access of what the processing plant can accommodate will be diverted to the storm water system.

- ***Seepage and pollution control***

During start-up the floor of the cell is covered by the tailings, which then consolidates to become a liner/barrier. Seepage will occur during this stage because of water ponding on bare ground. A 1.5mm thick high-density polyethylene (HDPE) liner could be used to line the cell, but this is not a specific requirement. Strip drains are laid down on the base of the cell, exiting into the perimeter trenches leading to the RWD. The strip drains are covered with a 150mm layer of clean river sand to form a base drain. The sand will later become clogged by fine tailings, but then assists with consolidation of the fine tailings to provide an effective tailings liner and also acts as a protective cover to the strip drains. A decant pump will be used to remove supernatant water as quickly as possible (Gecko, 2014).

- ***Conclusion***

Wet tailings disposal has advantages and disadvantages. These are discussed below:

ADVANTAGES	DISADVANTAGES
Plant produces tailings in a slurry form and the dewatering processes and equipment are less than what is required for dry disposal.	Only 30% to 50% with a maximum of 70% of the water reporting to the tailings can be recovered for re-use, the remainder will be lost to evaporation, seepage and retention in the heap.
Deposition procedures require only limited expenditure on equipment or supervision. According to the studies conducted on the project's effect on health and air quality, wet tailings disposal will result in reduced dust generation.	The Okanjande tailings will remain fairly permeable and will not form a seal vertically downwards. Therefore seepage must be collected and recovered to the plant for re-use. This will be achieved with the strip drains.
In any case a large portion of the processing water needs to be continuously bled off and be replaced by fresh water. This is required to keep the build-up of dissolved solids in the process water to an acceptable level.	The scarcity of water, the flat topography of the area (dams cannot be built with minimal earthworks to handle large fluid volumes) and the risk of groundwater contamination with sulphates and acidity, necessitate the building of well-constructed earthen dams with an impervious base, preferably with neutralizing capabilities.

3.4.3 The preferred TSF design option

From a technical and economical perspective the dewatered wet tailings deposition has been indicated as the preferred option by Gecko. However, from the alternative assessment provided above it can be concluded that both options - the wet and dry tailings disposal methods would be environmentally acceptable provided that the design measures are effectively implemented and upon adequate environmental control and reporting. This is further investigated in the subsequent sections of the report.

3.5 Concluding remarks on the alternatives

Various alternatives have been considered during the planning phase of the project. The preferred alternatives are:

- ❖ No-go vs. continuing of project: The continuation of the project could bring valuable economical development to the region and will not just benefit the

local populace but will also have national benefits. Therefore the preferred alternative is to continue with the project.

- Old vs. new location of the TSF: The old location of the TSF is positioned on a fracture between the Nosib and Swakop Group which could promote seepage and potential groundwater pollution. By positioning the TSF on the proposed new location, underlying lithologies can provide a neutralizing effect to any potential seepage. Furthermore, the dense Swakop Group marble and calc-silicate unit that underlies the new position has proven low permeability. This could potentially ensure long-term and safe storage of the tailings.
- On-site vs. off-site construction camp location: Both options represent some challenges but the availability of services in town (albeit under pressure) makes the off-site location of construction workers the preferred alternative. This is strengthened by neighboring farm owners who voiced their concern and objection towards uncontrolled movement (which is associated with on-site accommodation) of people on the farm and on the access road.
- Mining rates – Option 1 vs. Option 2: The underutilization of specialized equipment and workforce constitutes a high economic expense. Therefore, Option 2 is the preferred alternative. In this case, specialized equipment and skilled personnel will only be onsite during the mining operations (4 months). Thereafter they will no longer be an unnecessary expense.
- Wet vs. Dry tailings disposal: From an economical and technical perspective, wet tailings disposal presents the most advantages. Both dry and dewatered wet disposal are still investigated. Both options would be environmentally acceptable provided that best practice design and control measures are put in place. Sustainable use of water is of critical importance towards this decision.

In most instances a decision could be made that would satisfy the economical, technical and environmental (both social and biophysical) requirements. The following section describes the legal environment in which the project will be operated and provides national as well as international requirements for the project.

4 Legal and Regulatory Requirements

A summary of all pertinent international and national standards, guidelines, policies and laws of relevance to the Okanjande Graphite Project is presented below. The column entitled "Application to the Okanjande Graphite project" provides an indication of the relevance of each legal instrument to this project.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
NATIONAL LEGISLATION AND POLICY			
Namibian constitution	Namibian Constitution First Amendment Act, 1998	• General human rights (Articles 5-25) – e.g. eliminates discrimination of any kind, and the principles that undergird them (Article 95). • Article 95(l) of the Constitution of the Republic of Namibia: "maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future".	These principles are applied throughout the EIA process including the specialist studies and the public consultation process.
Environmental and Social Assessment and Management Systems	Environmental Management Act (7 of 2007)	• Requires for adequate public participation during the environmental assessment process for interested and affected parties to voice their	Follow the EIA process described in the act. Conduct public participation as part of

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		opinions about a project (Section 2(b-c)). • Requires the protection of Namibia's cultural and natural heritage, including its biological diversity for the benefit of present and future generations (Section 2(d)). • Requires that projects with significant environmental impact are subject to an environmental assessment process (Section 27).	the EIA process as described in the act. An Environmental Clearance certificate is required before the project can start.
	EMA Regulations GN 28-30 (GG 4878) (February 2012)	Listed activities requiring an Environmental Clearance Certificate (GN No 29 Annexure): • Section 3.1: "The construction of facilities for any process or activities which requires a license, right or other form of authorization, and the renewal of a license, right or other form of authorization, in terms of the Minerals (Prospecting and Mining) Act, 1992." • Section 3.3: "Resource extraction, manipulation, conservation and related activities." • Section 8.1: "The abstraction of ground or surface water for industrial or commercial purposes."	Conduct an EIA that covers all the components of the project, listed in the regulations.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		• Section 8.6: "Construction of industrial and domestic wastewater treatment plants and related pipeline systems." • Section 9.1: "The manufacturing, storage, handling or processing of a hazardous substance defined in the Hazardous Substances Ordinance, 1974."	
Mining related legislation	Minerals (Prospecting and Mining) Act No 33 of 1992	• Section 68(f) stipulates the conditions for compliance and notification during the construction and operation phase. • Section 50(i) requires "an environmental impact assessment indicating the extent of any pollution of the environment before any prospecting operations or mining operations are being carried out and an estimate of any pollution, if any, likely to be caused by such prospecting operations or mining operations". Even though this refers to the mining activities of the operation, "accessory works" are mentioned under the definitions of the Act, and may be interpreted as the processing activities of the operation, even though not explicitly required as	Requires that Environmental Reports are to be submitted every six months to the Mining Commissioner. Requires the specific consideration of pollution prior to and the anticipated pollution effects after the mining process has been completed in the EIA process. It also makes provision for a mine closure plan that prescribes steps necessary to remedy any damage caused by any prospecting and mining operations carried out. The following information or assessment

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		such in the act. • Section 54(2): If a reconnaissance area, prospecting area, retention area or mining area is abandoned…. The holder of the mineral license to which such area relates shall – (a) demolish any accessory works erected or constructed by such person in such area, except in so far as the owner of the land retains such accessory, works on such conditions as may mutually be agreed upon between such owner and person, and remove from such land all debris and any other object brought onto such land; (b) take all such steps as may be necessary to remedy to the reasonable satisfaction of the Minister any damage caused by any prospecting operations and mining operations carried on by such holder to the surface of, and the environment on, the land in the area in question. • Section 68(f) – Environmental Conditions	is necessary [called the Environmental Conditions]: a. Particulars of the existing conditions of the environment b. An estimate of the effect which the proposed operations may have c. Steps to be taken to prevent or minimise such effect d. This information forms a part of the Pro-forma Environmental Contract between the Government and the applicant and is attached as 'Appendix A' to the contract once the Ministry of Environment and Tourism (MET) and Ministry of Mines and Energy (MME) are satisfied with the submitted Environmental Conditions.
	The Mines, Works & Minerals Ordinance 1968 (Ordinance 20	• Regulates mining and exploration activities providing for environmental health and safety,	It encourages the conservation of natural resources at the Okanjande site,

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
	of 1968) of South West Africa	and environmental protection and conservation and occupational health and safety. • A safe site is the responsibility of the mine owner • The mine owner is responsible for restoration of the site • Land owners are to be compensated by the mine owners for operations usage: roads, wood, water, damage to property and land, diminution of the surface value of the land. • The minister can direct the mine owner to buy the land should operations prevent the proper usage of the land. • Conservation of natural resources on and around the land • Prevention, limitation, or treatment of pollution • Minimization of mining effects on adjoining or neighbouring areas and inhabitants • Protection of the environment • Conserving natural resources	describes how the landowners should be compensated for the use of their land and prescribes health and safety measures for the operation of the mine.
Biodiversity instruments	Forestry Act No 27 of 2004	• Provision for the protection of various plant species.	Some species that occur in the area are protected under the Forestry Act

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		• Section 22(1): It is unlawful for any person to "cut, destroy or remove any living tree, bush or shrub growing within 100 metres from a river, stream or watercourse on land that is not part of a surveyed erf or a local authority area without a license.	and a permit is therefore required to remove the species (e.g. Boscia albutrunca).
	The Nature Conservation Ordinance (1975) as amended through the Nature Conservation Amendment Act of 1996.	• Protects inter alia nature reserves, conservancies, the hunting and protection of wild animals, and the protection of indigenous plants. • Prohibits disturbance or destruction of the eggs of huntable game birds or protected birds without a permit. • Requires a permit for picking (the definition of "picking" includes damage or destroy) protected plants without a permit. • Preservation of Trees and Forests Ordinance: • Protection to tree species.	Conservation of wildlife on commercial farms operating as the Ovipuka commercial conservancy. Identify the existence of any protected plants and habitats of conservation concern to be addressed in the ESIA. List applicable biodiversity compliance issues in the EMP.
Heritage	National Heritage Act No 27 of 2004	• To provide for the protection and conservation of places and objects of heritage significance and the registration of such places and objects	Identify areas with archaeological potential. Conduct further archaeological assessment if required.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		• Establishes a body to govern matters relating to places and objects of heritage significance – National Heritage Council • Establishes a National Heritage Register	
Water resource management	The Water Resources Management Act (2004) is presently without regulations; therefore the Water Act No 54 of 1956 is still in force.	• A permit application in terms of Sections 21(1) and 21(2) of the Water Act is required for the disposal of industrial or domestic waste water and effluent. • Section 12: Permit for industrial use of water, to be obtained from the Minister in certain cases • Section 21: Purification and disposal of industrial water and effluents • Section 22: Prevent pollution of surface and ground water caused by a material capable of pollution. • Section 23(1): Prohibits the pollution of underground and surface water bodies. • Section 23(2): Liability of clean up costs after closure/ abandonment of an activity. • Protection from surface and underground water pollution.	Obligation not to pollute surface water bodies. The following permits are required in terms of the Water Act: • water abstraction permits; • domestic effluent discharge permits (site offices, construction camp); industrial effluent discharge permits; • water use for dust suppression; and water reticulation permits (pipelines).

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
	Water Act Regulations – Regulation 1277 of July 23 1971	• The control and utilization of public water • A waterworks of 20 000 m3 storage capacity may be constructed in a public stream by any person • Waterworks requiring greater capacity require a ministerial permit with added requirements; • Compensation to those affected by water storage, • The temporary increase or reduction of water quantity, • Measurement and regulation of water abstracted and conveyed • The user may be charged with use of public water.	Prescribes how public water, such as the groundwater that will be utilized during this project, should be managed to ensure that current users are not disadvantaged in the process.
Soil	Soil Conservation Act 76 of 1969	Consolidates and amends laws relating to the combating and prevention of soil erosion, the conservation, improvement and manner of use of the soil and vegetation and the protection of the water sources of Namibia.	Soil and water resources need to be protected in accordance with this act.
Explosives & petroleum	Explosives Act No 26 of 1956	Provides for the control of manufacturing, storage,	A licensed inspector is required to visit

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
products		sell, transport, importation, exportation and use of explosives. 5(1) "No person shall keep, store or be in possession of any unauthorized explosive unless it has been manufactured as provided by sub-section (1) of section three and is kept, stored or possessed in such a manner and in such quantities as have been approved in writing by an inspector." (9)(1)" No person shall use any blasting material- (a) unless he is in possession of a permit issued by or under the authority of an inspector; or (b) unless he is, while using such blasting material, under the immediate and constant supervision of a person who is in possession of such a permit."	the site to assess its safety and to issue a permit.
	Petroleum Products and Energy Act, No 13 of 1990 Petroleum Products and Energy Amendment Act, No 29 of 1994	Storage of petroleum products	Proponent needs to apply at MME for a consumer installation certificate.
Pollution and Waste	Atmospheric Pollution Prevention	• This legislation provides for the prevention of pollution of the atmosphere and for matters	Gecko will need to have measures in place to control dust and minimize

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
Management Bill	Act 11 of 1976	incidental thereto. • Provides for the 'control of noxious or offensive gases' and every premise where a scheduled process if carried on, has to be registered. Two main aspects of the legislation are relevant in the context of mining: • Dust control and the promulgation fur such purpose; • The control of pollution of the atmosphere by gases emitted by vehicles and the promulgation of regulations for such purpose.	potential air pollution. These measures are prescribed in the EMP.
Roads	Roads Ordinance 1972 (Ordinance no 17 of 1972) and Regulations	• Provides the laws relating to roads and incidental matters. • Legislation appropriate to environmental protection and conservation is embodied in Section 37(1)(b) and (c) and addresses the pollution of public roads.	Requires Gecko to minimize their impact on private and public roads.
	Road Traffic Ordinance 1967 (Ordinance 30 of 1967) and Regulations	• Consolidates the laws relating to motor vehicles and other vehicles and the regulation of traffic on public roads and to provide for matters incidental thereto.	Requires Gecko to consider potential traffic issues associated with the transport of materials and products. This is included in the EMP.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		• Section 119(1) deals with environmental protection conservation, and pollution of public roads	
Air pollution	Atmospheric Pollution Prevention Act (Act No 45 of 1965) (APPA).	Based on the stipulations of this act, the following parts are applicable: • Part II: Controls of noxious or offensive gases; • Part III: Atmospheric pollution by smoke; • Part IV: Dust control; and • Part V: Air pollution by fumes emitted by vehicles.	Include a requirement in the EMP that these regulations are to be adhered to.
Labour, working conditions and employment	Labour Act (1992)	• Health and Safety Regulations (not in force yet) (s135). • Minimum wages and working conditions including health and safety measures (s39-47).	Include a requirement in the EMP that these regulations are to be adhered to. Ensure that minimum wage and working conditions are stipulated in the contract.
	Affirmative Action (Employment) Act 29 of 1998	Provides for a set of affirmative action measures designed to ensure that persons in designated groups enjoy equal employment opportunities at all levels of employment and are equitably represented	Include a requirement in the EMP that this needs to be adhered to.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		in the workforce of a relevant employer.	
Public Health	Public Health Act 36 of 1919	Provides for the prevention of pollution of public water supplies.	Identify sites where potential pollution may occur, introduce mitigation measures where needed. The necessary compliance measures are to be included in the EMP.
NATIONAL, REGIONAL AND LOCAL PLANNING FRAMEWORK			
National Planning	Vision 2030	To be a prosperous industrialised country by 2030, developed by our people, and enjoying peace, harmony and political stability.	Ensure that the project outcome supports these objectives and that any negative influences on it are addressed in the EIA.
	National Development Plan 3 (NDP3) 2007/2008 – 2011/2012	Based on the Vision 2030, and provides the long term development framework for the country to achieve it. The main vehicle to translate the Vision 2030 into action. Includes policy directions and is based on eight key result areas, each corresponding to the main eight objectives of Vision 2030, under the themes Competitive economy, Infrastructure, Productive utilisation of natural resources and environmental sustainability, productive and	Ensure that the project outcome supports these objectives and that any negative influences on it are addressed in the EIA.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		competitive human resources and institutions, knowledge based economy and technology, quality of life, equality and social welfare, peace, security and political stability and regional and international stability and integration.	
INTERNATIONAL OBLIGATIONS			
International protocols and conventions	International Convention on Biological Diversity Rio de Janeiro (1992)	• Details the preservation of rare and endemic species. • Namibia is a signatory to this convention. Ratified by Namibia in 1997. • Article 14 requires that EIAs are carried out for projects that are likely to adversely affect biological diversity, avoid or minimize such effects, and where appropriate, allow for public participation.	Sites which are likely to affect biological diversity to be identified and assessed and the impacts avoided or minimized.
	The Convention on International Trade in Endangered Species (CITES) of 1973	Ratified by Namibia in 1990 the CITES regulates trade in endangered species, through listing in appendices (Relevant appendices include 1-2)	Vulnerable and threatened species will be identified and assessed and the impacts avoided or minimised.
	United Nations Framework Convention on Climate Change	Sets an overall framework for intergovernmental efforts to address the challenge posed by climate	Consider how this project could potentially affect and be affected by

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
	(UNFCCC) (1994), ratified by Namibia in 1995	change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. Under the Convention, governments: • gather and share information on greenhouse gas emissions, national policies and best practices • launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries cooperate in preparing for adaptation to the impacts of climate change. "Namibia, like all other SADC members, has signed and ratified both the UNFCCC and the Kyoto Protocol. As a non-Annex I Party to the Protocol, Namibia is not bound by specific targets for GHG emissions, however a number of global initiatives are being implemented, through donor and other support, to assist in the operationalization of the UNFCCC."	Climate Change.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
International performance standards and principles	International Finance Corporation (IFC)	The International Finance Corporation (IFC) developed Policy and Performance Standards (PS) on Environmental and Social Sustainability. It describes IFC's commitment, roles and responsibilities related to environmental and social sustainability. Eight PS were developed and are designed to help avoid, manage and mitigate risks and impacts and promotes doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project-level activities. PS broaden the suite of studies that are now done for ESIA's.	If international funding is sought, then Gecko Graphite will have to demonstrate its adherence to these requirements. This EIA and associated appendices are drafted so as to comply with the principles and standards.
	Equator Principles	The Equator Principles (10 in total) were developed in order to ensure that the projects that are financed by the Equator Principles Financial Institutions are developed in a manner that is socially responsible and reflect sound environmental management practices: • Principle 1: requires a project that is proposed for	If international funding is sought, then Gecko Graphite will have to demonstrate its adherence to these requirements.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		financing be categorised according to the magnitude of its potential impacts; • Principle 2: requires that a social and environmental assessment be conducted; • Principle 3: requires adherence to applicable International Finance Corporation (IFC) performance standards and Environmental Health and Safety guidelines; • Principle 4: requires the development of an Action Plan and Environmental Management System informed by the assessments conducted; • Principle 5: requires public participation and transparency; • Principle 6: requires the setting up of a compensation mechanism where grievances are unavoidable; • Principle 7: requires the independent review of the assessments conducted; • Principle 8: requires the borrower of category A and B projects to commit in writing that (among other agreements) they will comply to all relevant laws, both social and environmental,	

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
		laid out by the host country; • Principle 9: requires that category A and B projects be subject to ongoing environmental monitoring and reporting; and • Principle 10: requires annual public reports regarding the implementation of these principles.	
International standards and guidelines	Noise standards: South African National Standards (SANS) World Bank Guidelines on Pollution Prevention International Finance Corporation – 2007 General EHS Guidelines: Environmental Noise.	SANS (South African National Standards) 10103:2008 Version 6 -The measurement and rating of environmental noise with respect to annoyance and to speech communication.	The necessary management actions need to be included in the EMP.
	Air quality guidelines: World Health Organization ambient air quality guidelines	The aim of these guidelines is to provide a basis for protecting public health from adverse effects of air pollutants, to eliminate or reduce exposure to hazardous air pollutants and to guide national and local authorities in their risk management decisions.	In the absence of Namibian standards for air quality, the WHO guidelines will be used by the specialist. The necessary management actions need to be included in the EMP.

THEME	LEGISLATION/GUIDELINE/POLICY/ AGREEMENT	RELEVANT PROVISIONS	APPLICATION TO OKANJANDE GRAPHITE PROJECT
	Water quality guidelines:	The Department of Water Affairs uses a Draft set of water quality standards for effluent to be discharged or disposed of in areas with potential for drinking water source contamination; international rivers and dams and in water management and other areas. These are used as their standard under the Water Resources Management Act. South Africa is the only African country with an official set of water quality guidelines for discharges from land-based sources.	A set of water quality objectives need to be compiled for this project which would best protect the receiving environment. The necessary management actions need to be included in the EMP.

5 The Receiving Environment

5.1 Introduction

The legislation highlighted in the previous section emphasizes features of the biophysical and social environment that may need specific protection during project implementation. The collection of information on the receiving environments, coupled with the issues identified during the consultation process ensure that enough is known about the study area to make informed decisions with regard to planning, construction and operation of the proposed project.

The baseline descriptions that follow are based on information provided in the 1991 Environmental Baseline study (Walmsley Environmental Consultants, 1991) and have in some cases been updated based on the specialist studies done for the current EIA. Where applicable, vulnerability ratings have been provided to the environmental features. Vulnerability, as it is used in this section, refers to "the susceptibility of an environmental feature to suffer harm or its inability to withstand the effects of a hostile environment before potential impacts are taken into account. " Ratings are provided according to the following criteria (Table 5-1).

Table 5-1: Definitions of each of the vulnerability ratings.

VULNERABILITY RATING	CRITERIA
LOW	The environmental feature will be negligibly affected by the potential impact and has the ability to withstand negative effects without being adversely affected.
MEDIUM	The environmental feature will be moderately susceptible to suffer harm and will therefore be negatively affected by the activity albeit not adversely.
HIGH	The environmental feature will be severely affected by the potential impact as it is highly susceptible to suffer harm and lacks the ability to withstand the negative effects of the activity.

5.2 Climatic conditions of Otjiwarongo

Rainfall in the Otjiwarongo area is fairly constant at 400 – 500 mm per year. It occurs mainly during November to April, with the highest rainfall rates recorded in January and February. Moist air from the north-east is forced upward by hills in the area, causing the rising air to cool and condensate as rain (Mendelsohn, Jarvis, Roberts, & Robertson, 2009). According to the water study conducted for this investigation (Hydrosearch, 2014) the following maximum rainfall totals (Table 5-2) can be expected during a storm event:

Table 5-2: Summary of the expected maximum rainfall totals (mm)

PERIOD (YEARS)	24-HR MM	8-HR MM	2-HR MM	0.5-HR MM
1:100	160	144	115	74
1:50	130	117	94	60
1:20	100	90	72	46
1:10	81	73	58	37
1:5	65	59	47	30
1:2.3 (MEAN)	50	45	36	23

Otjiwarongo experiences high evaporation rates between 1 820 – 1 960 mm/year. These rates are highest during the warm summer months before the rainfall season starts, because of high solar radiation, high temperatures and low humidity. The Otjiwarongo area falls within the highest solar radiation zones in Namibia (Mendelsohn, Jarvis, Roberts, & Robertson, 2009). Incoming solar radiation increases from sunrise (06:00) to reach a maximum at midday (12:00 – 13:00) and then decreases until sunset (19:00). The temperature range is also significant, ranging between -1.9°C and 37.2°C. The highest temperatures are experienced in January and the lowest in June. During the day, temperatures increased to reach maximum at around 17h00. Ambient air temperatures decreased to reach a minimum at around 05h30 hours i.e. just before sunrise. Relative humidity in the study area varies between <10% to 60% during both the least humid month and the most humid month. Average relative humidity is at a maximum (60%) during summer mornings and at a minimum (<10%) on winter afternoons (Mendelsohn, Jarvis, Roberts, & Robertson, 2009).

According to Airshed Planning Professionals (2014) (See APPENDIX D) the wind field is dominated by airflow from the eastern sector during the summer, autumn and winter months with the strongest winds experienced mainly during the day in winter. Night-time winds are

generally of lower velocity than during the day. A shift in wind patterns occurs during the spring when wind comes primarily from the south and south east.

5.2.1 Air quality and carbon footprint

Climatic conditions play an important role in determining the atmospheric dispersion potential of an area. According to Airshed Planning Professionals (2014) air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers. Precipitation is another important component since it represents an effective removal mechanism of atmospheric pollutants, as well as a natural mitigation measure to entrained and windblown dust sources. Wind speed and insolation (solar radiation) determine the level of dispersion or dilution of pollutants in the air. Low wind speeds and no insolation (night) or weak insolation due to overcast conditions limits the dilution of pollutants. Conversely, unstable conditions are conducive to good dispersion potential and occur with moderate winds and strong insolation. The wind disperses pollutants horizontally and unstable conditions dilute pollutants in a deeper layer of the atmosphere.

Since there are no major sources of air pollution in the project area and the atmospheric dispersion potential is generally good, ambient air quality there may be regarded as good (Airshed Planning Professionals, 2014).

Gaseous emissions from vehicle exhaust are regarded as the main source contributing to air pollution. These emissions contain greenhouse gases (GHGs), including carbon dioxide and the various forms of Nitrous Oxide (NOx), which are natural components of the atmosphere, and are released and absorbed through the biosphere and oceans. Radiation from the sun heats the earth's surface. As the surface is heated it emits further radiation that is trapped in the earth's atmosphere by GHGs. When too much heat is trapped in the atmosphere it causes a rise in the mean temperature. This rise in temperature causes knock on effects collectively known as climate change.

Such changes to the global climate include those relating to the average long-term rainfall and temperature, and the resultant increases in average global air and ocean temperatures, melting of snow and ice, rising global mean sea level, and changes in ocean salinity and altered wind patterns. The changes also include increased frequency of extreme weather events including droughts, heavy rainfall events, heat waves and increased intensity of tropical cyclones. Both changes in the average climate and an increase in the number and intensity of extreme weather events will be catastrophic for life on the planet due to the effects on physical safety, food security, water availability and other factors. Different geographical regions will be affected in different ways at diverse times and to varying extents.

The sensitivities relating to air quality and climate change are listed in Table 5-3 below.

Table 5-3: Sensitivities related to air quality and climate

ENVIRONMENTAL FEATURE	SENSITIVITY	POTENTIAL IMPACT
Ambient air quality	Ambient concentrations of criteria air pollutants exceeding health based guidelines	Increase occurrence of respiratory illness, or exacerbation of existing conditions with exceedances of SO_2, NO_x or PM_{10} guidelines

5.3 Topography, geology and soils

The Otjiwarongo area is characterized by a relatively flat plain with inselbergs and low ridges standing out above the general land surface. The general elevation is between 1300-1600m.

The proposed mine and plant sites are situated on the lower west-facing slopes of one of the ridges. The proximity of other low ridges to the site means that the project will be effectively screened from most public view sites (Figure 5-1 and Figure 5-2). The highest point on the site (1628m) is found to the east from the envisaged development. From this point, the land slopes away towards the northwest, west and southwest. The lowest point is at an elevation of 1583m, giving a total local relief of 45m.

In addition to the obvious mining-related reasons for looking at the geology (discussed in Chapter 2 of this report), it is necessary to understand the geochemistry of the ore body and overburden materials in order to assess their pollution potential on this project.

According to Hydrosearch (2014) the general area around the site is underlayn by the Damara Supergroup, Nosib Group and Swakop Group. In the project area the Nosib and Swakop Groups are folded into a tight overturned syncline with the Swakop Group forming the core. The graphite ore body is hosted in the Nosib Group. At the core of the syncline lower Swakop Group lithologies are present and include marble, calcsilicate and a rim of biotite schist. The Nosib Group rocks consist mainly of quartzite and the ore is known to contain about 4% sulphide minerals (mainly pyrite, pyrrhotite and chalcopyrite (Namib Hydrosearch, 2014). Larger concentration of sulphide mineralisation is also known to occur within the Nosib Group. At shallow levels the ore body rock is weathered and the sulphide content is reduced and is occasionally absent due to weathering and oxidation. The Swakop Group is represented by calcsilicate and marble rocks. Small granitic intrusions are present within the units.

Figure 5-1: East-west elevation profiles across the project site.

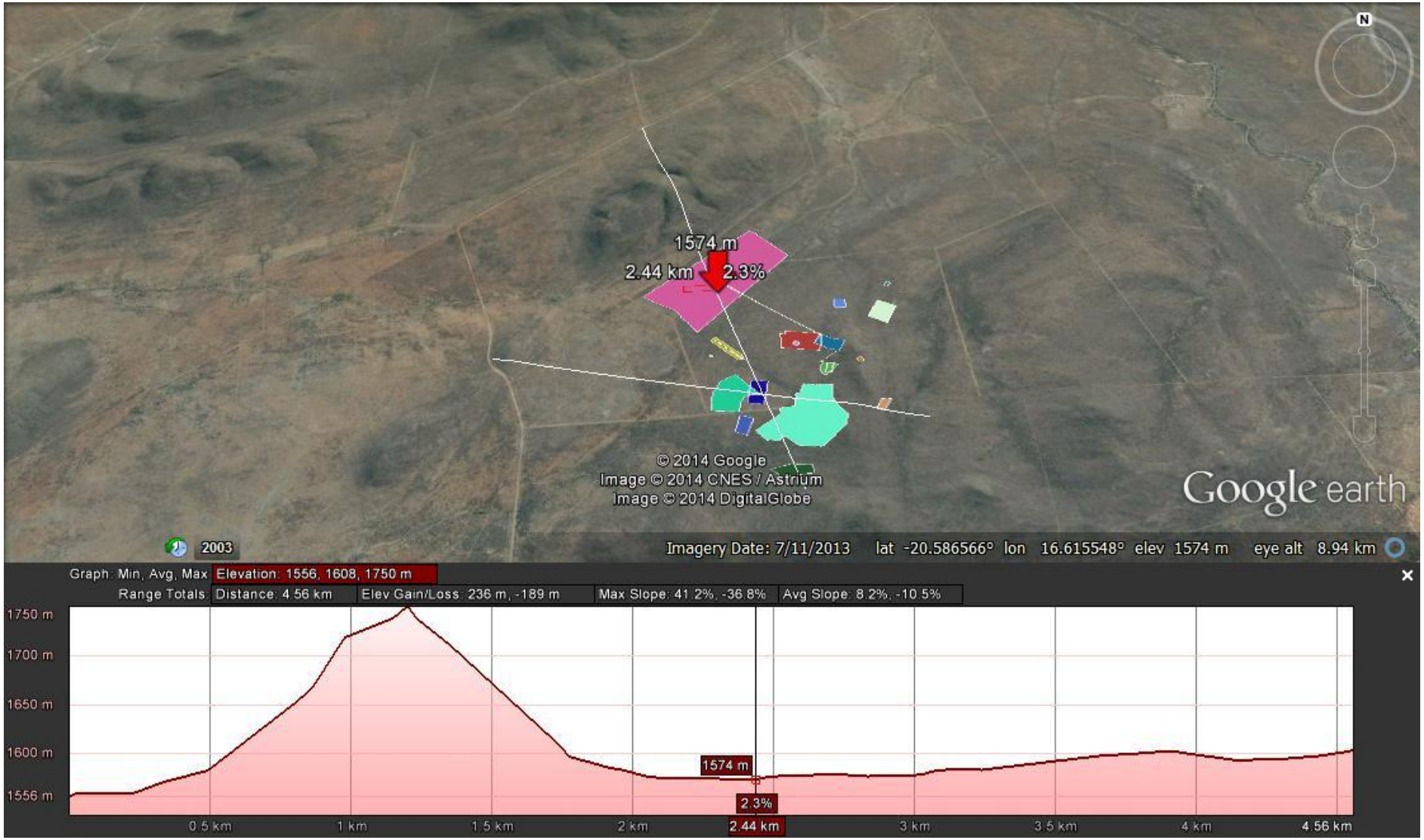

Figure 5-2: North-south elevation profiles across the project site

According to Walmsley Environmental Consultants (1991) three main soil types occur in the vicinity of the mine, plant and tailings dump. The mine and plant areas are characterized by dark, thin, sandy loams of the Glenrosa form, over weathered rock. Oakleaf soils occur lower down in the valley and are characterized by dark, loamy-sand topsoils over a dense, gritty, sandy sub-soil. Over the marbles and calc-silicates Brandvlei soils have developed and are characterized by dense zones of calcrete nodules. Walmsley Environmental Consultants (1991) further states that although most of the soils are thin, they have a fairly high inherent fertility and can therefore be valuable in rehabilitation.

Because of the thin soils and low rainfall, the land has a very low agricultural capability rating. Only grazing is suitable on the lower slopes and valley areas, but the soils on the upper parts of the ridges are too thin to support any specific land use (Walmsley Environmental Consultants, 1991).

Due to their relatively high permeability, the dense vegetative cover and moderate natural slope gradients (over most areas of the project site), the potential for erosion under undisturbed conditions is low (Walmsley Environmental Consultants, 1991). The situation may however change once the vegetative cover has been removed and the soils disturbed during construction.

A description of the potential impacts associated with topography, geology and soils is provided in Table 5-4 below:

Table 5-4: Potential impacts associated with the topography, geology and soils in the project area.

ENVIRONMENTAL FEATURE	DESCRIPTION	POTENTIAL IMPACT/ENHANCEMENT
Topography	Undulating landscape	Some areas of the mine site may be visible from the B1 and the private road.
Geology	Rock types are characterized in terms of their acid producing and acid neutralizing capacity. Both the pyrite and pyrrhotite are□acid-generating materials when they become exposed to air and water.	High potential for groundwater pollution, especially from the mine pit, waste rock dump site and the TSF.
Soils	Thin but relatively fertile soils Has a high sand content that	• Soil erosion • Fertile top soils may be used in the rehabilitation of the mine.

ENVIRONMENTAL FEATURE	DESCRIPTION	POTENTIAL IMPACT/ENHANCEMENT
	promotes infiltration.	• Potential infiltration of polluted water from containment areas that are not lined (e.g. the TSF).

5.4 Hydrology

5.4.1 Surface water

According to Hydrosearch (2014) (See APPENDIX E) the Nosib Group lithologies at the mine site create a natural surface water divide causing the surface ephemeral channels to originate and flow in northeast, southwest and northwest directions. The northeast and southwest flowing channels roughly follow the contact zone of the Nosib and Swakop Groups. A northwest flowing drainage at a high angle to the strike across the Swakop Group outcrop follows a possible fault across the marble and calcsilicate unit.

Considering runoff on the project site, Hydrosearch (2014) indicates the following areas as significant in terms of critical storm rainfall and runoff:

- Runoff into Tailings Dump 1 (from the north-west)
- Runoff into the Waste Rock Stockpile (from the south-east)
- Runoff into the Mine Pit (eastern corner)
- Runoff into the Run of Mine Stockpile (from the east)
- Rainfall volumes onto Tailings Dump 1
- Rainfall volumes onto Tailings Dump 2
- Rainfall volumes onto the Waste Rock Stockpile
- Rainfall volumes into the Mine Pit

The runoff from catchment areas leading to various mine structures planned is of concern (Table 5-5).

Table 5-5: Storm runoff (from Hydrosearch, 2014)

ITEM(S/P = STOCKPILE)	CATCHMENT AREA M2	RAIN MM	INITIAL LOSS MM	RUNOFF VOLUME M3
INTO TAILINGS DUMP 1	636,000	160	10	95,400

ITEM(S/P = STOCKPILE)	CATCHMENT AREA M2	RAIN MM	INITIAL LOSS MM	RUNOFF VOLUME M3
INTO WASTE ROCK S/P	33,100	160	10	4,965
INTO MINE PIT	45,600	160	0	7,296
INTO ROM S/P	17,800	160	0	2,848

The following sensitivities and potential impacts have been identified on the surface water component (Table 5-6):

Table 5-6: Sensitive hydrological component

COMPONENT	SENSITIVITY	VULNERABILITY	POTENTIAL IMPACT
SURFACE WATER RUNOFF	Surface water drainage	High	Contamination of surface water through runoff entering mine structures and stockpiles.

5.4.2 Groundwater

Groundwater is the main source of water in the area along with some minor dams and ephemeral streams. It is abstracted through boreholes and a few hand dug wells on streambeds. A hydro-census was conducted as part of the water study for the project (Namib Hydrosearch, 2011). From the investigation it was found that up to 50% of the boreholes in the area were found abandoned most likely due to low yields (less than 3m3/h) or other water quality issues related to elevated nitrate content.

In terms of groundwater characteristics and supply, the following key points are discussed in more detail in the report (Namib Hydrosearch, 2014):

- Water obtained from boreholes is primarily used for livestock watering and domestic supply.
- Groundwater flow directions are closely related to surface water drainage directions. It drains from the mine site towards the northwest and follows the surface drainage towards to the northeast and southwest. This indicates unconfined aquifer conditions with groundwater divides where groundwater flow is restricted.

- Recharge is limited. Water filters through the weathered layer of material at a very slow rate until it reaches even less permeable material at depth.
- Groundwater discharge could occur from underlying fracture / fault systems.
- The marble – calcsilicate unit underlying the proposed TSF location has low permeability with low groundwater potential.

In terms of groundwater quality, the 2014 water study (Namib Hydrosearch, 2014) concluded that the values obtained for pH, electrical conductivity, total dissolved solids, alkalinity, iron and sulphate content in groundwater are indicative of sulphide phase oxidation and interaction with carbonate rocks. The wide range of values obtained during his study is expected to occur naturally (without interactions from the mine) and forms the basis against which future monitoring of water quality will be assessed.

Another component investigated during the 2014 water study (Namib Hydrosearch, 2014) was to determine the neutralising potential and acid generating potential of rock formations underlying the study area, particularly the ore and waste rocks and the lithologies underlying the TSF. The following are concluded:

- The proposed new location of the TSF is located on an area of marble and calcsilicate units which has non-acid producing characteristics.
- The granite and pegmatite intrusives within the Swakop Group, and soil derived from the bedrock are also non-acid producing.
- Fresh waste rock is acid producing while weathered waste rock has variable net acid potential depending on the sulphide mineral content. The waste rock stockpiles will have large components of sulphide-containing quartzite and are positioned on the same rock type. Any leachate emanating from this stockpile is likely to be acidic. Effluent emanating from neutralised ore and waste rock may have elevated sulphate and total dissolved solids content.

Groundwater potential of the area is poor but is of local importance in the absence of other supply sources for farm residents and livestock farming. The following sensitivity and potential impact have been identified on the ground water component (Table 5-7):

Table 5-7: Sensitive groundwater component

COMPONENT	SENSITIVITY	VULNERABILITY	POTENTIAL IMPACT
GROUNDWATER	Infiltration of contaminant from mining activity into groundwater	High	Effluent from mining activity including possible AMD entering groundwater.

COMPONENT	SENSITIVITY	VULNERABILITY	POTENTIAL IMPACT
	Low groundwater potential	High	Sustainability of groundwater resources

5.5 Vegetation

During the 1992 EIA (Walmsley Environmental Consultants, 1992) field observations and species collections were used to establish whether any rare, threatened or ecologically important plant species occur on the mine site. This information was substantiated by Pallett (2014) (See APPENDIX F) during his site assessment on the area's biodiversity with special regards to its avifauna. Below is a combined summary of the two studies, providing a description of the vegetation at the mine site:

- The habitat across the entire EPL and infrastructure route is thornbush savanna growing on fairly thin soil with occasional patches of bedrock at the surface.
- The area is densely encroached by two dominant invasive species, namely Acacia mellifera subsp. detinens and Dichrostachys cinerea (sickle bush), and there is generally very little grass. Upper hill slopes with rocky substrate are less densely encroached. The degree of encroachment also varies across the neighbouring farmlands, with large areas of Highlands, Osdam and Okanjande severely encroached, while Doornlaagte is generally more open with more grass cover. These farms are used for low-intensity cattle farming.
- The habitat of the project area is widespread and homogeneous in central Namibia, and contains no unique or singular features of high ecological importance. None of the species found on site are rare, threatened or endangered.

Table 5-8 below provides a brief summary of the most common tree species at the mine site. A more comprehensive list is available from Walmsley Environmental Consultants (1992).

Table 5-8: Dominant tree species.

FREQUENCY OF OCCURRENCE	COMMON SPECIES	NOTES
Dominant trees	Acacia mellifera, Acacia fleckii, Dichrostachys cinerea and Combretum apiculatum	Grow to about 3 m tall. Understorey is mostly low herbs and predominantly bushy growth of Grewia flavescens
Less frequently taller trees	Ziziphus mucronata, Acacia	

FREQUENCY OF OCCURRENCE	COMMON SPECIES	NOTES
	erioloba and A. tortilis, Terminalia prunoides, and Boscia albitrunca, Commiphora pyracanthoides	
	Kirkia acuminata	Upper slopes
	Combretum imberbe trees	Close to river washes

The relatively large trees occurring on the project site are important environmental features. The information is summarised in Table 5-9.

Table 5-9: Vulnerability ratings associated with vegetation (from Pallet, 2014).

COMPONENT	SENSITIVITY	VULNERABILITY	POTENTIAL IMPACT
LARGE TREES - THE FEW LEADWOOD TREES (COMBRETUM IMBERBE) GROWING ALONGSIDE EPHEMERAL RIVER CHANNELS, AND THE MOUNTAIN SERINGA TREES (KIRKIA ACUMINATA) GROWING ON HILL SLOPES.	Large trees are aesthetically pleasing. They are important ecologically for the food they provide (fruits and pods), shelter and nesting sites for hole-nesting birds such as hornbills, and large raptors that nest in relatively taller to minimize disturbance. Large trees perform important roles in cycling nutrients from depth to the surface, their roots hold the soil together (reducing erosion), and they funnel rainwater down the trunk to the soil where it is shaded so enhancing soil moisture for other plant growth.	High in specific, local areas that will be cleared, but this is a small proportion of the total area.	Destruction of large trees due to construction activities

5.6 Fauna

Based on the 1991 baseline report (Walmsley Environmental Consultants, 1991) a total of 16 mammal species have been recorded on the farms Okanjande and Highlands. Table 5-10 below provides a summary of fauna that are likely to occur in the project area.

Table 5-10: Dominant fauna species likely to occur in the project area.

	SPECIES
PREDATORS	Leopard, cheetah, blackbacked jackal and Cape fox
HERBIVORES	Gemsbok, kudu, red□hartebeest, duiker and Damara dikdik
REPTILES	Leopard tortoise (Geochelone pardalis), Kalahari tent tortoise (Psammobates oculiferus), Southern African python (Python natalensis), Namibian dwarf python (Python anchietae), Veld leguaan (Varanus albigularis)

In addition to the 1991 report, Pallett (2014) provides an updated list of potential bird species likely to occur in the quater-degree square of the project area. Pallett (2014) states that the thornbush savanna has an abundance of bird life with 140 species recorded on the Namibian Avifauna Database as potentially occurring in the area.

According to Pallett (2014) ten bird species occur in the project area that could be affected by, or could affect power lines near the mine site (Table 5-11).

Table 5-11: Bird species likely to interact with power lines.

BIRD SPECIES	COLLISIONS AND ELECTROCUTIONS	HABITAT DAMAGE	NESTS ON TOWERS
BATELEUR	X	X	
LAPPET-FACED VULTURE	X	X	
MARTIAL EAGLE	X	X	
TAWNY EAGLE	X	X	
VERREAUXS' EAGLE	X		
WHITE-BACKED VULTURE	X	X	
MACCOA DUCK	X	X	
PIED CROW			X
RED-BILLED BUFFALO WEAVER			X
SOCIABLE WEAVER			X
KORI BUSTARD	Collision 22kV HLPCD 2011 Collision 220kV 2013		

BIRD SPECIES	COLLISIONS AND ELECTROCUTIONS	HABITAT DAMAGE	NESTS ON TOWERS
SECRETARY BIRD	Collision 22kV HLPCD 2011		
NAMAQUA SANDGROUSE	Collisions 220kV 2013		

The following sensitivity and potential impact have been identified on fauna occurring in the project area (Table 5-12).

Table 5-12: Vulnerability ratings of fauna in the project area (Pallet, 2014).

COMPONENT	SENSITIVITY	VULNERABILITY	POTENTIAL IMPACT
RAPTORS	Electrocutions and collisions on power lines. Drowning in steep-sided reservoirs. Disturbance at nests	Medium - High	Small population reductions due to mortalities, and displacement due to noise, vehicles and other facets of mining and generally increased human activity.
BUSTARDS	Collisions against power lines	Medium - High	Small population reduction due to mortalities.
HORNBILLS AND PARROTS	Loss of feeding and nesting sites Possible increase in illegal parrot trafficking as a result of increased human presence in the area	Low - Medium	Very small population reductions due to potential reduction in breeding sites.
REPTILES	Tortoises collected for food, snakes and leguaans killed unnecessarily when encountered	Low - Medium	Small population reductions due to human presence

5.7 Archaeology

During the 1992 EIA (Walmsley Environmental Consultants, 1992) a ground survey of the Okanjande area was carried out during which detailed records of all archaeological sites were made in the field. The findings were further augmented through research carried out at the National Archives in Windhoek. Since the results of the archaeological study provided sufficient information regarding the locations of archaeological sites, the study was not repeated during the current EIA. This section provides a summary of the findings of the previous study.

The historical significance of the Okanjande area lies in the fact that during the early 1900s Okanjande served as an important military outpost of the German Shutztruppe. In addition to this, pre-colonial artefacts were also found in the area. The findings of the archaeological assessment are provided in Table 5-13 below with reference made to the map provided in the 1992 EIA (Walmsley Environmental Consultants, 1992) (Figure 5-3):

Table 5-13: Summary of archaeological findings obtained during the 1992 EIA (Walmsley Environmental Consultants, 1992).

HISTORICAL PERIOD	ARCHAEOLOGICAL FINDINGS	SITE DESCRIPTION	SITE LOCATION (SEE FIGURE)
PRE-COLONIAL	Early Stone Age tools in quartzite	Higher slopes of the main range of hills	Site 4
		Isolated hill to the south	Site 15
	Middle Stone Age tools	Isolated examples: primary tool accumulation may have been preserved beneath unconsolidated younger sediments in the vaolley areas.	Sites 3 and 8
	Late Stone Age affinities	Indistinct rock paintaings on an outcrop of quartzite schist close to the track from the Rooibult camp to the district road. The paintings are in monochrome dark red and have been rendered unidentifiable by localised spalling and thick sinter-like deposit. A small cairn found near the paintings indicates a probable grave site.	Site 10
		Group of five shallow depressions engraved on a low outcrop of quartzite. The approximately 1 m high outcrop is situated on the western side of a seasonal vlei and probably served as a natural hunting blind.	Site 11

HISTORICAL PERIOD	ARCHAEOLOGICAL FINDINGS	SITE DESCRIPTION	SITE LOCATION (SEE FIGURE)
		Approximately 1km south-east, surrounding rocks are polished in places up to 3 m above the floor of the drainage line. This is an indication that elephants once visited these waterholes.	
	Pastoral settlement	Pottery associated with a trimmed basesherd from a mid-nineteenth century glass bottle. Quern stones and boulders brought down from the surrounding hills used to anchor hut supports.	Site 6
		Extension of homestead marked with two pairs of small boulders placed 1.5m apart and orientated roughly north-south.	Site 7 and 9
		Traces of hut settlements and quern stones. Evidence suggests the likelihood of other homestead sites located within a few kilometres of the available waterholes. The water points were known to Europeans at the turn of the century and formed part of the trek route to Otavi, the next waterholes after Okanjande being those of Otjiwarongo.	Sites 1, 2, 13 and 14
COLONIAL HISTORY	Okanjande	• Occupied by German colonial forces at the time of the Herero uprising • Battle of Okanjande fought on 16 January 1904. • 4th Company of the Schutztruppe established control over Okanjande reserve. • Okanjande base served as a prison camp for British subjects intervened by the Germans at the outbreak of the 1914-1918 war.	Site 16 – ruin of a German heliograph post Site 17 – main buildings of the German station

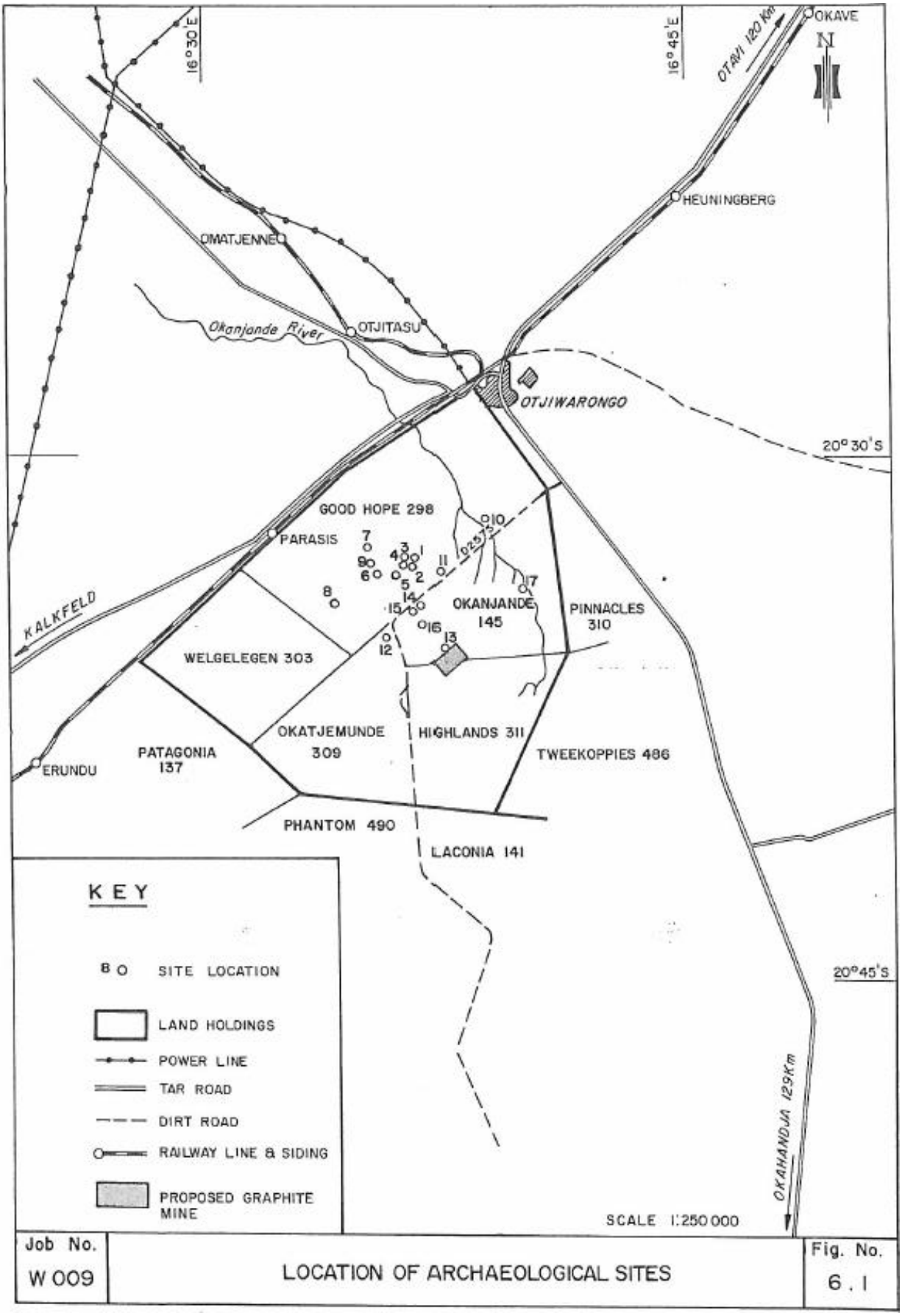

Figure 5-3: Original map of archaeological findings near the mine site (from (Walmsley Environmental Consultants, 1992)

5.8 Socio-economic environment

5.8.1 Otjozondjupa region

A specialist study was conducted on the socio-economic implications of the project (Saayman, 2014)(See APPENDIX G). The report indicates that the Otjozondjupa Region has a population of 143,903 people. Yet the population density of the region (at 1.4 people per square kilometre), is lower than the national average of 2.6. This can be ascribed to the fact that a large portion of the region constitutes communal land where communal farming activities take place.

The main urban centres include Grootfontein, Otavi and the town of Otjiwarongo. The latter is also the administrative capital of the region. Approximately 54 % of the population live in urban areas, whereas the remaining 46% live in rural areas. Many of the people work on commercial farms in the region. The majority of the households are dependent on wages and salaries as a form of income. Only 10 % have listed farming as their main income source. In terms of unemployment, 37 % of the labour force, i.e. those between the ages of 15 and 60 years, are unemployed (Saayman, 2014).

The economic activities of the Otjozodjupa Region are dominated by agriculture, tourism and mining. Table 5-14 below provides a summary of the main economic activities in the region:

Table 5-14: Main economic activities in Otjozondjupa Region.

ECONOMIC ACTIVITY	DESCRIPTION
AGRICULTURE ON FREEHOLD LAND	• Livestock farming, mainly sheep and cattle for the Namibian meat market as well as for export. • Commercial rain-fed crop cultivation takes place at the Tsumeb-Otavi-Grootfontein triangle where maize is grown predominantly. • Few irrigation farming venture.
LARGE AND SMALL SCALE AGRICULTURE ON COMMUNAL LAND	Almost 40 % of the land use constitutes communal land. Crops are cultivated while cattle and goats are herded. The produce from communal farms are either used for personal consumption or sold at local markets, while livestock is seen as a form of capital investment, used for draught power, meat and milk production or to sell commercially.
TOURISM AND CONSERVATION	The Waterberg Plateau Park is the main tourist attraction and conservation area in the Otjozondjupa Region. It is approximately 405 km² in size, and protects a diverse group of flora and fauna. The mine is located in the Ovipuka Commercial conservancy that has the

ECONOMIC ACTIVITY	DESCRIPTION
	protection and conservation of wildlife and natural habitats as its primary focus. The main road linking central Namibia to the northern regions runs through the region. Consequently, many tourists pass through en-route to destinations such as the Epupa Falls in the Kunene Region, the Etosha National Park and Caprivi Region. A number of lodges, hunting farms and private conservation areas are found along this route in the Otjozondjupa Region.
MINING ACTIVITIES	• Okarusu Fluorspar Mine: Open cast fluorspar mine located approximately 48 km north of Otjiwarongo. The mine employs approximately 350 permanent employees, 30 temporary employees, 125 contractors and 5 expatriates. Some of the employees are accommodated on-site, while others reside in Otjiwarongo. While this mine did not pay any corporate tax during 2012 but it paid N$3.8 million in royalties. • Ohorongo Cement (Pty) Ltd: Located close to Otavi. Commenced production in December 2010. Employs approximately 300 permanent employees, 10 temporary employees, but no contractors. Employees are housed in Otavi. The mine indicated a loss of N$218.6million by the end of 2012, hence it did not pay any taxes or royalties. • B2Gold mine: Located approximately 70 km north of Otjiwarongo en-route to Otavi. Construction commenced in 2013. During the peak construction phase, an estimated 600 people are employed.

5.8.2 Otjiwarongo

Otjiwarongo has an estimated population of about 40,000 people and has shown a growth rate of 2.5 % per year. According to Saayman (2014) the town has been faced with an influx of both job seekers and those who have procured employment opportunities in or near the town. This can be attributed to large developments in the area which includes the new N$49 million town centre development, and the B2Gold Otjikoto Gold Mine.

The economics of the town mainly revolves around agriculture as the majority of the businesses are related to this sector (Saayman, 2014). Other key economic activities include the pharmacy factor, the global polymer and toilet factory as well as retail and petroleum.

The influx of workers put pressure on Otjiwarongo's infrastructure. This is exacerbated by the surrounding geomorphology of the area (leaving certain areas inundated during the rainy season) and the restricted ground- and surface (fresh) water resources. A description of the

various infrastructural resources and the problems Otjiwarongo is facing is presented in Table 5-15.

Table 5-15: Description of the infrastructural limitations at Otjiwarongo.

INFRASTRUCTURE/RESOURCES	DESCRIPTION	
HOUSING	The Municipality of Otjiwarongo is currently faced with a large shortcoming, especially with residential erven for the low and middle income residents.	
	EXISTING NR OF ERVEN	
	Formal	6,000
	Informal	9,000
	REQUIRED NR OF ERVEN	
	Middle And Low Income Areas (Needed By 2016)	1,000
	Informal Areas	2,000
	Industrial And Business	30-40 (72 erven ready to be serviced)
	B2gold	120
	Approval for these erven has been lodged with the Surveyor General, but there are delays due to a backlog at this office. Of the eleven extensions submitted to the Surveyor General, approval for four of these extensions has now been granted. Each extension has on average between 150 and 300 erven. Further legal work is required, before it can be serviced and made available to the public.	
WATER	• NamWater supplies water to the municipality who is then responsible for distribution to the town. The average monthly water consumption of the town is 110 – 120,000 m³. Since 1998, the municipality has seen a decrease in water consumption. • Water for the town is sourced from 21 boreholes, with an additional five boreholes on standby. No pressures are currently experienced in terms of the available volumes of water.	
ELECTRICITY	CENORED supplies electricity to the town. Cost of electricity has spiked since the distribution service was ceded to CENORED. No pressures are	

INFRASTRUCTURE/RESOURCES	DESCRIPTION
	currently experienced in terms of the available electricity.
HEALTH SERVICES	There are five general private practitioners, three pharmacies, a biokineticist and a state and private hospital. This private hospital, Medicity, is equipped to handle the majority of the emergency and critical cases, and has an Intensive Care Unit (ICU). Other medical services in town include four private dentist practices and two state dentists. Since there are no clinics or health care centres in the informal area, the Multi-Purpose Centre provides treatment for HIV/AIDS.
EDUCATIONAL FACILITIES	Currently the town has five primary schools, six secondary schools and two combined schools as well as two private schools. Faced with a number of challenges including a shortage of qualified teachers as well as classrooms. There is also a shortage of schools in the informal settlement area. An influx of people to this area, bringing with their families, further adds to this problem.
ROAD INFRASTRUCTURE	Otjiwarongo is located on a main transport route between Windhoek, the coast and northern towns. All traffic commutes through the town, mainly along Main Street in the Central-Business Area (CBD). High number of trucks with no truck ports or parking areas (truck stops) along the route. Traffic circles have been introduced at the southern and northern entrances of the town. This poses yet another problem for heavy motor vehicles which sometimes cannot turn wide enough and thus go over the circle instead of around it. The municipality is currently not equipped to construct modern roads to accommodate the high traffic volume. They are however considering the upgrade of Longstreet, to alleviate traffic congestions in the town.

There are differing land uses surrounding the various components of the project. The activities that stand to be potentially affected by the proposed project in some way or another are listed in Table 5-16 and the locations of these activities are depicted in Figure 5-4.

Table 5-16: Surrounding land use activities to the proposed project.

PROJECT COMPONENT	NEIGHBOURING LAND USE ACTIVITY
Entire project	Ovipuka Commercial Conservancy: 13 of the surrounding farms form part of the conservancy including farm Highlands and Portion 1 of Okanjande farm. The key objectives of the

PROJECT COMPONENT	NEIGHBOURING LAND USE ACTIVITY
	conservancy are to: • promote wildlife conservation and management • protect, regulate and improve the status and variety of wildlife (including mammals, birds, invertebrates, indigenous plants, wetlands and other habitats) • protect all farming and personal property • initiate the resettlement of game species into the area • promote conservation awareness • co-ordinate and initiate the sustainable utilization of wildlife • improve veld condition by practicing sound veld management principles • co-operate with nature conservation institutions..
Project mining and processing facilities:	Farms Osdam and Highlands: Activities include farming (250 cattle on Highlands and 400 cattle, 200 sheep and 200 goats on Osdam), and hunting. The latter constitutes the main source of income for the farmers. Local and international hunters pay the farmers large sums to hunt kudu, oryx, hartebeest and warthogs.
	Other farms including Okanjande, Okatjemunde, Goodhope, Pinnacles and Tweekoppies: Hunting tourism and farming and farm Okanjande has a horse stud of about 30 horses which roams in camps. The farm has a cattle herd of approximately 200.
	Through town along Main Street: Runs through the CBD and is surrounded by businesses, shops, residential erven, fuelling stations, restaurants and coffee shops, as well as medical facilities. Being the main road, it is a busy area used by the local community, tourist or visitors to the area or those passing through en-route to northern regions, including trucks.
B1 Road into town to TransNamib:	At the Southern entrance turn left at traffic circle and continue along Langstreet: Surrounded by residential erven as well as a school and its sport grounds.

The key sensitivities are summarised in Table 5-17 below.

Table 5-17: Summary of Key Socio-Economic sensitivities

COMPONENT	SENSITIVITY	VULNERABILITY	POTENTIAL IMPACT
NAMIBIAN ECONOMY	Payment of taxes and royalties contributes to the GDP.	Low	The proposed project will contribute to the Namibian economy through taxes and royalties paid.
REGIONAL AND LOCAL ECONOMY	Regional and local businesses that deliver goods and services can be affected by an increase in spending.	Medium	The proposed project will contribute to the local and regional economies through job creation and spending on goods and services.
HOUSING	There is currently a shortage of erven and available housing. This matter is worsened by the backlog experienced at the office of the Surveyor General.	High	If employees are housed in Otjiwarongo during the construction and operational phases, it will further add to the existing pressure on a lack of erven and housing. An influx of job seekers will also contribute to this pressure.
EXISTING SERVICES AND INFRASTRUCTURE	Available services such as sewerage and road infrastructure, have reached full capacity. The schools have already exceeded their capacity. Water infrastructure in the informal areas is insufficient in meeting the existing demand.	Medium	An influx of job seekers as well as new construction and operational employees will add to existing pressures on available services. The transport of employees and the product and materials needed, will add to the pressure on existing road infrastructure.
TRAFFIC	The main road in town is faced with traffic congestion.	Low	An increase in traffic brought about by this

COMPONENT	SENSITIVITY	VULNERABILITY	POTENTIAL IMPACT
	The road to the mine site is a proclaimed private road and is maintained by the farmers themselves.		project can add to the existing pressure on road infrastructure or result in conflict.
UNEMPLOYMENT	The Otjozondjupa Region has an unemployment rate of 37 % and Otjiwarongo 40 %. New job opportunities are needed to alleviate this problem.	Low	A number of people can benefit from job creation in both the construction and operational phases of this project.
INFLUX OF JOB SEEKERS	Recent developments in the area have contributed to an influx of job seekers.	Medium	The news of the development of a new mine can contribute to the existing trend of influx of job seekers to Otjiwarongo. This might be an issue especially during the implementation phase as the local infrastructure will not be able to handle the increased pressures. The informal settlement area is likely to expand.
SURROUNDING LAND USES	Change to existing land uses.	Low	A change in surrounding land uses and depreciation of the value of property can result in conflict.
CATTLE AND WILDLIFE	Since cattle and wildlife are important in sustaining the economic activities of the farmers, it is sensitive to change.	Low to Medium	Construction and operational workers can engage in illegal poaching activities of cattle and wildlife. Nuisances such as noise or dust can also impact on farming or hunting tourism activities.

COMPONENT	SENSITIVITY	VULNERABILITY	POTENTIAL IMPACT
HEALTH	Since Otjiwarongo has an HIV/AIDS prevalence rate of 25 % and is located on a key transport node, it is sensitive to the spreading of disease.	Medium	An influx of job seekers and a mobile workforce of 300-400 people during the construction phase can contribute to the spreading of disease.
SOCIAL ILLS	There is an existing problem of drug and alcohol abuse, even in some schools. Crime and burglaries are also a problem.	Low	An influx of job seekers and increased unemployment can result in further aggravation of this existing trend.

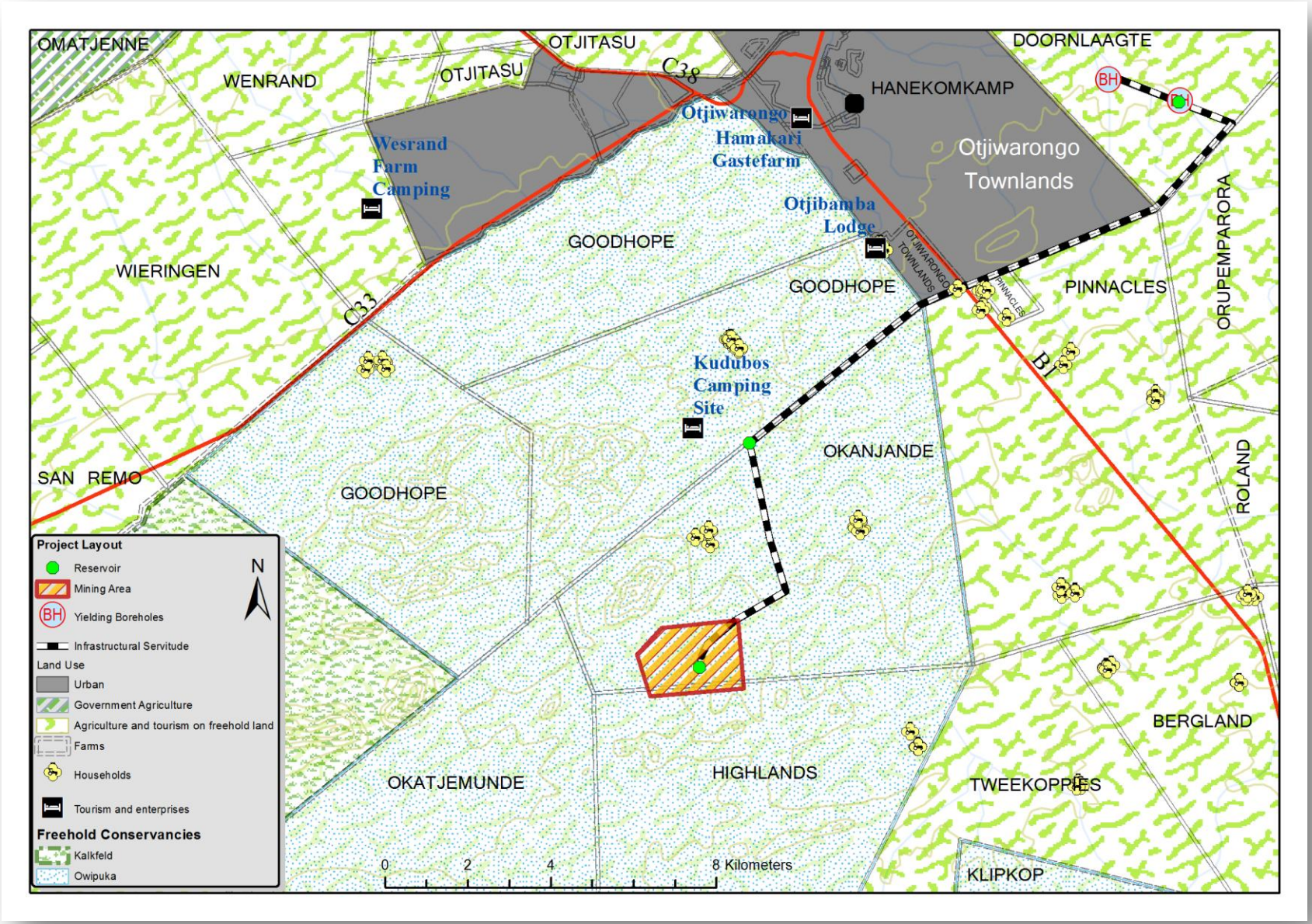

Figure 5-4: Proximity of farms and homesteads to the various project components

6 Public Participation

6.1 Introduction

Public participation forms an important component of an Environmental Impact Assessment (EIA) as it provides potential interested and affected parties (I&APs) with a platform whereby they can raise any issues or concerns relevant to the proposed project. This assists the consultant in considering the full spectrum of potential impacts and to what extent further investigations are needed.

In addition, the public participation process also grants I&APs an opportunity to review and comment on all the documents produced throughout the EIA process. This is done in accordance with both the Namibian Environmental Management Act of 2007, as well as international best practice principals.

Because the scope of the EIA was largely determined during the 1992 study, it was decided that the bulk of the work done previously is still useful and need not be repeated. For this EIA, the first phase (scoping phase) was therefore concluded in a consultation document (APPENDIX C) that reported on the updated consultation and disclosure initiatives undertaken under the current Environmental Assessment (EA) process. The process included consultation meetings with the relevant authorities and the community. Thereafter a consultation report containing the issues identified during the first phase was circulated to registered I&APs. More details on the public participation process and its findings can be viewed in the consultation document (APPENDIX C).

A list of all comments received on the consultation document is provided in the Issues and Responses Trail (APPENDIX C).

6.2 Public Concern

During the public consultation process, a number of key issues were brought to Enviro Dynamic's attention. These issues determined the scope of the full Environmental Impact Assessment. Key concerns are listed below in Table 6-1 and further assessed in Section 7.

Table 6-1: Summary of issues raised during the public consultation process

THEME	PUBLIC CONCERNS
BIOPHYSICAL ENVIRONMENT	❖ Ecological and habitat disturbance/loss being perpetuated by the establishment of the mine ❖ Groundwater pollution and monitoring ❖ Sustainability of the groundwater resources and the effect on neighbouring

THEME	PUBLIC CONCERNS
	farmers' boreholes ❖ Effect of blasting on neighbouring borehole structures and changes in groundwater resources ❖ Ability of game to move across the pipeline ❖ Effect of dust on the health of animals, humans and vegetation ❖ Birds nesting on power line structures
SOCIO-ECONOMIC ENVIRONMENT	❖ Potential reduction in property values of neighbouring farms ❖ Employment and skills availability ❖ The effect of the project on the town infrastructure and health services ❖ Effect of the project on the local economy ❖ Creation of employment ❖ Security issues associated with the accommodation of workers on site and general activities of the mine
REHABILITATION	❖ Condition of the road and subsequent maintenance during construction and operation activities. ❖ Rehabilitation of the site at the end of life of the mine.
DUST AND NOISE	❖ The effect of noise and vibrations resulting from blasting and mining and operation activities.

6.3 Public feedback

The Environmental Impact Assessment Report will be circulated in a similar fashion as the Public Consultation Report:

- ❖ It will be circulated to all I&APs for their comments, allowing for a two week comments period.
- ❖ The comments received on the report will be collated into a Comments and Responses Trail that include statements of how the comments were considered and incorporated into the final Report.

After incorporating the comments, the final version will be submitted to the Directorate of Environmental Affairs in application for an Environmental Clearance Certificate for this project development.

7 Impact Assessment

7.1 Identification of key issues

By considering the impacts identified during the 1992 EIA study and the issues raised during the public consultation process of the current EIA (as contained in the Public Consultation Report) the following key impacts have been highlighted:

- Impact on air quality, human and animal health and vegetation,
- Impact on groundwater and surface water hydrology,
- Impact on fauna and flora,
- Impact on the socio-economic environment,
- Cumulative impact associated with the implementation of the project.

Specialist studies were therefore commissioned to conclusively determine the significance of these impacts and identify workable mitigation measures where applicable. The findings of these investigations form the focus of the rest of this chapter.

7.2 Methodology Employed for the Impact Assessment

The criteria used to describe the significance of the impact on the particular environmental component are contained in the Table 7-1 below:

Table 7-1: Definitions of the criteria used to determine the significance of impacts

	DESCRIPTION
NATURE	Reviews the type of effect that the proposed activity will have on the relevant component of the environment and includes "what will be affected and how?"
EXTENT	Geographic area. Indicates whether the impact will be within a limited area (on site where construction is to take place); local (limited to within 25km of the area); regional (limited to ~200km radius); national (limited to the borders of Namibia); or international (extending beyond Namibia's borders).
DURATION	Whether the impact will be temporary (during construction only), short term (1-5 years), medium term (5-10 years), long term (longer than 10 years, but will cease after operation) or permanent.

DESCRIPTION	
INTENSITY	Establishes whether the magnitude of the impact is destructive or innocuous and whether or not it exceeds set standards, and is described as none (no impact); low (where natural/ social environmental functions and processes are negligibly affected); medium (where the environment continues to function but in a noticeably modified manner); or high (where environmental functions and processes are altered such that they temporarily or permanently cease and/or exceed legal standards/requirements).
PROBABILITY	Considers the likelihood of the impact occurring and is described as uncertain, improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of prevention measures).
SIGNIFICANCE	Significance is given before and after mitigation. Low if the impact will not have an influence on the decision or require to be significantly accommodated in the project design, Medium if the impact could have an influence on the environment which will require modification of the project design or alternative mitigation (the route can be used, but with deviations or mitigation) High where it could have a "no-go" implication regardless of any possible mitigation (an alternative route should be used).
STATUS OF THE IMPACT	A statement of whether the impact is positive (a benefit), negative (a cost), or neutral. Indicate in each case who is likely to benefit and who is likely to bear the costs of each impact.
DEGREE OF CONFIDENCE IN PREDICTIONS	Is based on the availability of specialist knowledge and other information.

7.3 Assessment of impacts

7.3.1 Impact on air quality, human and animal health and vegetation

Assessing the impacts of the mine's emissions on the receiving environment involves three components: Firstly, available meteorological data is used to determine the dispersion potential in the area. Baseline evaluations are then made based on an analysis of background ambient concentrations and dust fallout rates. Thirdly, an emissions inventory is established that identifies the sources of emission, and quantifies each source's contribution to ambient air pollution concentrations. This is then assessed to determine the impacts of particulates and gas emissions on wildlife, soils and human health.

During the Air Quality Impact and Health Risk Assessment (Airshed Planning Professionals, 2014) it was established that the wind field is dominated by winds from the eastern sector. The strongest winds occur mainly during the day and in winter. Night-time winds are generally lower than during the day. During summer, autumn, and, winter months, winds are generally from the eastern sector, with a shift in wind patterns from the south and south-east during spring. Because no data exits for ambient concentrations in the area, reference was made to general background PM10 concentrations reported for Namibia.

- ***Sources of emissions***

Findings from the emissions quantification and dispersion modelling indicated the following pollutants and their sources of emission (Table 7-2):

Table 7-2: Main pollutants and their sources expected from the project (from Airshed Consulting, 2014).

POLLUTANT	EMISSION SOURCE AND CONTRIBUTION	IMPACT SOURCE AND CONTRIBUTION	SIMULATIONS AND THE PROJECT AREA
SULFUR DIOXIDE (SO2)	• Sulphide oxidation is the main emission source (98.76%) and the main impacting source • Vehicle tailpipe emissions to a lesser extent (0.83%) • Drier emissions (0.41%)	Weathered sulphide oxidation is the main impacting source	Simulated annual average SO2 concentrations during the operational phase exceed the SA NAAQS directly to the west of the mine site and predicted daily and hourly SO2 concentrations exceed the WHO IT1, EC Limit and SA NAAQS in the valley around the mine

POLLUTANT	EMISSION SOURCE AND CONTRIBUTION	IMPACT SOURCE AND CONTRIBUTION	SIMULATIONS AND THE PROJECT AREA
			area.
PARTICULATES	• Vehicle entrainment on all haul- and access roads (55.5%) • Loading and unloading of trucks (23.4%) • Drilling and blasting (11.6%) • Wind-blown dust from TSF (5.1%) • Crushing and screening (4.4%)	• Vehicle entrainment on all haul - and access roads and Loading and Unloading of trucks are the main impacting sources • Impacts from Drilling and Blasting are insignificant due to the frequency (up to four times a year) and duration of these activities. • Windblown dust is a low impacting source due to the frequency of occurrence (only when wind speeds exceed 5.8 m/s which happens 6.9 percent of the time.	• Highest daily and annual average PM10 concentrations during the construction phase were predicted to exceed the WHO IT3 and SA NAAQS in the immediate vicinity of the processing plant area, but not outside the mine boundary. • Highest daily and annual average PM10 concentrations during the operational phase with dry tailings disposal were predicted to exceed the WHO IT3 and SA NAAQS in the immediate vicinity of the processing plant area, the TSF and the opencast pit, but not outside the mine boundary.
NITROGEN DIOXIDE (NO2)	• Vehicle tailpipe emissions based on tier-1 emission factors (78.3%) • Drier emissions (21.7%)	• Vehicle tailpipe emissions is the main impacting source group	• Simulated annual average NO2 concentrations exceed the WHO AQG and SA NAAQS directly to the west of the mine site and predicted hourly NO2 concentrations

POLLUTANT	EMISSION SOURCE AND CONTRIBUTION	IMPACT SOURCE AND CONTRIBUTION	SIMULATIONS AND THE PROJECT AREA
			exceed the WHO AQG and SA NAAQS in the valley to the west of the mine area.
CARBON MONOXIDE (CO)	• Regarded as insignificant	• Impacts expected to be well below (<1%) of the international standards and guidelines.	• Insignificant
VOCS	• Regarded as insignificant	• Impacts expected to be well below (<1%) of the international standards and guidelines.	• Insignificant

No information is currently available regarding the sulphide oxidation rate at the Okanjande graphite mine site and according to Airshed Planning Professionals (2014) various mechanisms can influence the SO2 emissions, including moisture content, ambient temperature and soil pH as well as soil bulk density. In their assessment a conservative approach was followed to determine the upper limit SO2 concentration. It was assumed that oxidation will not only occur at the bottom of the pit, but also on the sidewalls. Sulphide oxidation emissions from the waste rock dump, TSF and ROM pad were also included. However, this approach had the following limitations:

- ❖ in reality the open pit surface and side-walls, the waste rock dump surface and TSF surface will not comprise entirely of sulphide ore resulting in smaller areas where oxidation would occur; and
- ❖ sulphide can also be dissolved and then oxidized with the potential reaction products from sulphide oxidation including acidity, sulphur species, total dissolved solids, and metals.

Because of these limitations, a great deal of uncertainty exists around the emission strengths. The assessment is nonetheless based on the precautionary principle and allowed for conservative upper limit concentrations (Airshed Planning Professionals, 2014).

- ***Impacts of particulates and gas emissions on humans, animals and vegetation***

The nearest farm house is located 2.2 km away from the project site and according to Airshed Planning Professionals (2014) will not to be affected by particulates and gas emissions from the mine. The health risk assessment therefore only focused on the impact on mine personnel. The findings from the health risk assessment are summarized below (Table 7-3):

Table 7-3: Health effects associated with the main emissions/particulates expected on the project.

	HUMAN HEALTH	ANIMAL	VEGETATION
SO2	• Increases the prevalence of chronic respiratory disease and the risk of acute respiratory illness. Due to it being highly soluble, sulphur dioxide is more likely to be adsorbed in the upper airways rather than penetrate to the pulmonary region. • People with asthma are the most sensitive group	• Acute inhalation of SO2 produces bronchia constriction, increases respiratory flow resistance, increases mucus production and has been shown to reduce abilities to resist bacterial infection. • Short exposures to low concentrations of SO2 (~2.6 mg/m³) have been shown to have immediate physiological response without resulting in significant or permanent damage. • Sulphur dioxide can produce mild bronchial constriction, changes in metabolism and irritation of the respiratory tract and eyes in cattle. • Chronic exposure can affect mucus secretions and result in respiratory damage similar to chronic bronchitis.	• May affect the selenium (an essential nutrient for livestock) content of forage plants.
NO2	• NO2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. Exposure to NO2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function. • Exposure to high concentrations of NO2 can lead to pulmonary oedema and pneumonitis.	• NO2 concentrations upward of 40 ppm (72 mg/m³) resulted in signs of toxicity (eye irritation, lacrimation and laboured breathing) in various animals (mice, rats, guinea pigs, rabbits and dogs). Below concentrations of 20 ppm (36 mg/m³) signs of irritation were minimal and no effects on behaviour were noted.	

	HUMAN HEALTH	ANIMAL	VEGETATION
PM10	• Scientific studies have linked breathing particulate matter to a series of significant health problems, including: • aggravated asthma • increases in respiratory symptoms like coughing and difficult or painful breathing • chronic bronchitis • decreased lung function • premature death	• Acute exposures (4-6 hour single exposures) of laboratory animals to a variety of types of particles, almost always at concentrations well above those occurring in the environment have been shown to cause decreases in lung function, changes in airway defence mechanisms and increased mortality rates. • At ambient concentrations PM10 exposures will not lead to high mortality.	• PM10 is not likely to impact on vegetation with dust fallout the main particulate fraction of concern.

It should be noted that none of the health screening levels as discussed in the table above are predicted to be exceeded anywhere in the study area. By implementing the proposed mitigation measures, the mining activities are expected to result in low risk to the on-site personnel as well as off-site residents (Airshed Planning Professionals, 2014a) (APPENDIX H). Without mitigation, the impacts are likely to exceed the ambient air quality limits outside the mine boundary.

- ***Mitigation***
  - ❖ All haul roads as well as the access road should be treated with chemical surfactants to minimize dust emissions. The temporary roads should be sprayed with water in combination with a chemical stabilizer.
  - ❖ The TSF should be constructed according to the wet design specifications where the tow-wall or starter wall would serve as a windbreak on the windward side of the TSF. The dormant and dried out areas should be vegetated and continually re-vegetated to minimize windblown dust emissions from the surface areas. The beach areas should be kept moist to minimise the wind erosion potential.
  - ❖ The crusher should be fitted with an extraction system as per the design specifications.
  - ❖ Water sprays should be applied at all material handling operations should these result in visual dust plumes.
  - ❖ The vehicle fleet should comprise of new technology engines (tier-2 or tier-3 compliant engines) to ensure low combustion emissions. Vehicles should be maintained and serviced regularly and vehicle idling times should be limited to minimize NO2 emissions and impacts.

- ❖ Low sulphur fuels should be used for the drier and mine vehicle fleet and equipment.

- ***Monitoring***
  - ❖ SO2 concentrations should be sampled to:
  - Determine the impact of vehicle exhaust emissions and sulphide oxidation on the surrounding environment.
  - Determine the impact of sulphide oxidation on employee health.
  - Determine the rate of sulphide oxidation.
  - ❖ A dust deposition network comprising at least six single dust fallout units should be establish to collect dust fallout due to routine operations, as well as the dust fallout during high wind periods.
  - ❖ A PM10 monitor should be installed downwind from the mining operations and downwind from the TSF.
  - ❖ A passive SO2 and NO2 sampling campaign should be conducted bi-annually (summer and winter) at the same locations used for dust fallout monitoring.
  - ❖ Occupational PM10, SO2 and NO2 exposure should be measured regularly. Personal samplers can be issues to selected employees covering various mining activities and areas. This is useful to obtain a data record of exposure levels at the mine.

- ***Summary***

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
CONSTRUCTION PHASE									
PM2.5 HUMAN HEALTH AND ANIMAL IMPACTS	Respiratory and cardiovascular effects	On-site	Temporary	Low	Low	Medium	Low	Water sprays on roads, material handling points and cleared areas	Very Low
PM10 HUMAN HEALTH AND ANIMAL IMPACTS	Respiratory and cardiovascular effects	Local (<5 km)	Temporary	Medium	Medium	Medium	Medium	Water sprays on roads, material handling points and cleared areas	Low
SO2 HUMAN HEALTH AND ANIMAL IMPACTS	Chronic respiratory disease and acute respiratory illness	On-site	Temporary	Low	Low	Medium	Low	Use low sulfur fuels, regular maintenance and repair	Very Low
NO2 HUMAN HEALTH AND ANIMAL IMPACTS	Chronic respiratory disease and acute respiratory illness	On-site	Temporary	Low	Low	Medium	Low	Use tier-2 or tier-3 compliant engines, minimize vehicle idling times, regular maintenance and repair	Very Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
CO HUMAN HEALTH AND ANIMAL IMPACTS	Reducing oxygen delivery to the body's organs	On-site	Temporary	None	Low	Medium	Low	Use tier-2 or tier-3 compliant engines, minimize vehicle idling times	Very Low
VOC HUMAN HEALTH AND ANIMAL IMPACTS	Adverse health effects	On-site	Temporary	None	Low	Medium	Low	Use tier-2 or tier-3 compliant engines,	Very Low
DUSTFALL NUISANCE IMPACTS	Nuisance impact – visual dust	On-site	Temporary	Medium	Medium	Medium	Medium	Water sprays on roads, material handling points and cleared areas	Low
DUSTFALL IMPACTS ON ANIMALS	Dust deposition on vegetation that the animals feed on	On-site	Temporary	Medium	Medium	Medium	Medium	Water sprays on roads, material handling points and cleared areas	Low
OPERATIONAL PHASE – WET TAILINGS									
PM2.5 HUMAN HEALTH AND ANIMAL IMPACTS	Respiratory and cardiovascular effects	On-site (only at plant and mine)	Long Term	Medium	Medium	High	Medium	Water sprays and chemical suppressants on roads, water sprays at crusher and materials handling	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
								points and vegetation cover on TSF	
PM10 HUMAN HEALTH AND ANIMAL IMPACTS	Respiratory and cardiovascular effects	On-site (only at plant and mine)	Long Term	High	Medium	High	Medium	Water sprays and chemical suppressants on roads, water sprays at crusher and materials handling points and vegetation cover on TSF	Low
DUSTFALL NUISANCE IMPACTS	Nuisance impact – visual dust	On-site (only at plant and mine)	Long Term	Medium	Medium	High	Medium	Water sprays and chemical suppressants on roads, water sprays at crusher and materials handling points and vegetation cover on TSF	Low
DUSTFALL IMPACTS ON ANIMALS	Dust deposition on vegetation that the animals feed on	On-site (only at plant	Long Term	Medium	Medium	High	Medium	Water sprays and chemical suppressants on	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
		and mine)						roads, water sprays at crusher and materials handling points and vegetation cover on TSF	
OPERATIONAL PHASE – DRY AND WET TAILINGS									
SO2 HUMAN HEALTH AND ANIMAL IMPACTS	Chronic respiratory disease and acute respiratory illness	Local (<5 km)	Long Term	High	Low	Low	Medium	Use low sulfur fuels, regular maintenance and repair Good ventilation in open-pit	Low
NO2 HUMAN HEALTH AND ANIMAL IMPACTS	Chronic respiratory disease and acute respiratory illness	Local (<5 km)	Long Term	High	Low	Medium	Medium	Use tier-2 or tier-3 compliant engines, minimize vehicle idling times, regular maintenance and repair	Low
CO HUMAN HEALTH AND ANIMAL IMPACTS	Reducing oxygen delivery to the body's organs	On-site	Long Term	Low	Low	Medium	Low	Use tier-2 or tier-3 compliant engines, minimize vehicle idling times	Very Low
VOC HUMAN	Adverse health	On-site	Long Term	Low	Low	Medium	Low	Use tier-2 or tier-3	Very Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
HEALTH AND ANIMAL IMPACTS	effects							compliant engines,	
DECOMMISSIONING PHASE									
PM2.5 HUMAN HEALTH AND ANIMAL IMPACTS	Respiratory and cardiovascular effects	On-site	Short-term (1-5 years)	Low	Medium	Medium	Low	Water sprays on roads, material handling points and cleared areas, full vegetation cover on TSF and waste dump	Very Low
PM10 HUMAN HEALTH AND ANIMAL IMPACTS	Respiratory and cardiovascular effects	On-site	Short-term (1-5 years)	Low	Medium	Medium	Low	Water sprays on roads, material handling points and cleared areas, full vegetation cover on TSF and waste dump	Very Low
DUSTFALL NUISANCE IMPACTS	Nuisance impact – visual dust	On-site	Short-term (1-5 years)	Low	Medium	Medium	Low	Water sprays on roads, material handling points and cleared areas, full vegetation cover on TSF and waste dump	Very Low
DUSTFALL	Dust deposition on	On-site	Short-term	Low	Medium	Medium	Low	Water sprays on	Very Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
IMPACTS ON ANIMALS	vegetation that the animals feed on		(1-5 years)					roads, material handling points and cleared areas, full vegetation cover on TSF and waste dump	

7.3.2 Impact on groundwater and surface hydrology

- ***Description***

The proposed mine is located on elevated ground with ephemeral streams flowing north, southwest and northwest. These streams flow for short durations during the rainy season and according to Namib Hydrosearch (2014) no permanent surface water bodies are present in the area. Surface runoff from the elevated areas will be diverted so that it does not enter the mine structures. A perimeter trench will be established to prevent possible contamination of the ground water.

Groundwater in the area is replenished primarily through direct infiltration of rainwater. Namib Hydrosearch (2014) describes two main lithological units that underlie the project area namely the Nosib Group and Swakop Group (both of the Damara Supergroup). Based on the findings of the groundwater exploration and resource assessment study (Namib Hydrosearch, 2012), these rocks form separate aquifer units that have poor groundwater potential. This is supported by the fact that few boreholes are operated in the area. Groundwater, nonetheless, remains the primary source of water in the area and is used primarily for domestic supply and livestock watering. The groundwater source identified for mine supply (on the farm Doornlaagte) is independent of resources in the local mine area and will therefore have no influence on local supply.

The Nosib Group is made up of quartzite and hosts the graphite ore body. According to Namib Hydrosearch (2014) the ore body also contains variable amounts of sulphide minerals which could lead to possible contamination through Acid Mine Drainage. In contrast to the Nosib Group, the Swakop Group consists of marble and calcsilicate rocks. These rocks create aquifers under unconfined conditions that have low groundwater permeability and storage properties. The Acid Base Accounting Study undertaken by Namib Hydrosearch (2014) found that Swakop Group rock has non-acid producing/acid neuralizing properties which make it ideal for the siting of the TSF.

Table 7-4 below summarizes the findings of Namib Hydrosearch (2014) associated with the various components of the mine.

Table 7-4: Key findings of the hydrology study (2014).

MINE COMPONENT	FINDINGS OF HYDROLOGY STUDY (HYDROSEARCH, 2014)
MINE PIT	• Groundwater inflow volume is low. • Quality of the groundwater seepage into the pit is likely to be acidic due to oxidation of sulphide minerals and exposure to the atmosphere (oxygen). • May contain elevated levels of sulphate and iron.

MINE COMPONENT	FINDINGS OF HYDROLOGY STUDY (HYDROSEARCH, 2014)
	• Heavy metals may be mobilised from the oxidised sulphide phases and is likely to increase with time. • During the operation period of the mine the groundwater could be used as process water in the plant. The water will not be suitable for other use and may have to be neutralised with limestone or marble.
RWD	• The Return Water Dam (RWD) has to be located in the proximity outside of the TSF and ideally at the lowest point to the southeast of the proposed TSF1 site. • The Swakop Group marble calcsilicate lithologies are favoured for positioning the RWD. • An underlying fracture zone across the Swakop Group marble represents a groundwater discharge feature.
ROM	• Will consist of ore with variable amounts of sulphide minerals. • Could potentially release acidic effluent with infiltration of rainwater or storm water runoff.
WASTE ROCK STOCKPILE	• Heterogeneous material made up of weathered and fresh Nosib Group quartzite with variable amounts of sulphide minerals. • Could potentially release acidic effluent with infiltration of rainwater or storm water runoff, particularly when more fresh rock is mined at depth. • Storm water runoff and direct rainfall volumes are calculated to be small on this area. • Situated on Nosib Group rocks which could be acid producing.

In terms of the long term impacts of the mine pit after mine closure, Namib Hydrosearch (2014) identifies the following potential impacts should the mine pit be excavated to the maximum depth of 85 m:

- "If the mine pit remains unfilled after mining activity ceases it is likely to fill by groundwater seepage to a level in equilibrium with the surrounding groundwater table. The inflow rates are expected to be high when the pit is excavated but later flow are likely to be at low rates.

- This could lead to the formation of low pH, high sulphate and TDS water in the pit with possible dissolved metals that is concentrated by loss of water through evaporation. This will particularly apply to seepage from the pit walls above the water level and during seasonal fluctuations of flow and water levels.

- Possible infiltration and return of mine pit water to groundwater"

The deep water levels, low hydraulic conductivity, limited water in the dewatered tailings or deposited dry tailings and the addition of neutralising agents to the tailings could all work to ensure the security of the groundwater. Inflow rates into the mine pit are estimated to be low and could be neutralised if found to be acidic. If surface water is diverted away from the mine structures groundwater contamination through direct infiltration can be avoided. Namib Hydrosearch (2014) concluded that the general impact of the mine is seen to be limited and can further be reduced by implementing the recommended mitigation measures for possible impacts and by continuously monitoring the effectiveness of the mitigation measures during the operation and closure phases of the mine.

- ***Mitigation***

  - Berms should be constructed to channel runoff away from the entire north-western boundary of the TSF to avoid erosion and damage to the embankments and possible mixing with effluent in TSF perimeter trenches. The runoff should be discharged to the natural drainage channel in these directions. No runoff should enter the perimeter trench or reach the embankment of the TSF.
  - Berms on the upslope side would stop runoff entering the stockpiles or mine pit given the relatively small volumes of runoff expected. The runoff is to be diverted away from the stockpiles towards the southwest flowing natural drainage. Contact or mixing of runoff with the stockpile material or effluent is to be avoided.
  - The proximity to the contact zones along the north-west and south-east side require that the trenches are lined and any effluent collected and directed to the RWD. Sufficient depth of the perimeter trench is required to intercept any lateral flow along the soil zone.
  - The RWD needs to be lined with strip drains to prevent seepage. Steps will also have to be taken to minimise the retention time in the RWD and to pump this water as a priority for use in the plant. The RWD will be designed to accommodate storm water (1:100 rainfall event) and to contain surface runoff from the TSF. Dilution of the effluent to a significant level is expected under these conditions.
  - Diversion of storm water drainage with berms and peripheral trenches to collect seepage water is recommended together with close monitoring. On closure of the mine the stock piles are to be graded to encourage runoff and limit infiltration. The surface is to be covered with soil and vegetated. The protective berms diverting surface flow are to remain to avoid any erosion of the soil cover.

- ❖ The addition of crushed limestone (marble) to the stockpile to raise the pH and precipitate metals in the long term is recommended. On closure of the mine the stock piles are to be graded to encourage runoff and limit infiltration. The surface is to be covered with soil and vegetated. The protective berms diverting surface flow are to remain to avoid any erosion of the soil cover.
- ❖ Secure the pit against inflow of surface runoff water and discharge.
- ❖ The suitability of the water accumulated in the mine pit for use in the plant is to be evaluated.
- ❖ The mine pit could be dosed with acid neutralisation material such as marble or limestone. Reactions may be hindered by formation of 'armour' of Fe(OH)3 and has to be ground to sand size particles for effective neutralisation in the long term (The Global Acid Rock Drainage Guide). By implementing the recommended monitoring measures, it will be possible to define if and when the equilibrium can be reached. The monitoring program should be adjusted going forward based on these results.
- ❖ On closure the mine pit should be cordoned off to avoid access and use by animals and humans.

- ***Monitoring***

A summary of the key monitoring actions is provided in Table 7-5:

Table 7-5: Summary of ground and surface water monitoring.

RISK ITEM	MONITORING
SEEPAGE FROM TSF	• Monitoring and accounting of water inflow and outflow from the TSF. Water quality monitoring. • Water recovery rates from decant pond and RWD • Inspection and estimate of outflow from under drains
QUALITY OF SEEPAGE FROM TSF	• Monitoring boreholes in the active TSF cell, embankments and base. • Monthly field water quality parameter measurements • Quarterly water quality analyses
STRUCTURAL INTEGRITY OF THE TSF	• Monthly inspection of embankment walls for erosion and ponding of water along embankments • Water level monitoring within embankments.
CONTAMINATION AFTER CLOSURE	• Water level within TSF • Groundwater level

RISK ITEM	MONITORING
OF TSF	• Inspection of TSF walls
CONTAMINATION AND RISK AFTER CLOSURE FROM MINE PIT	• monitor water levels • monitor water quality
WASTE WATER DISPOSAL	• Volume and quality

- ***Summary***

The table below provides a summary of the potential impacts related to ground and surface water (Table 7-6):

Table 7-6: Assessment of impacts related to surface and groundwater.

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
OPERATIONAL PHASE									
SEEPAGE FROM TSF	Negative: Formation of AMD and contaminate groundwater	Local	Long term	Medium	Probable	High	High	Dewatered tailings, reclaim water, locate on marble, calcsilicate lithology. Recovery boreholes if necessary.	Low
STRUCTURAL INTEGRITY OF THE TSF	Negative: Contaminate groundwater by erosion of tailings	Local	Long term	Medium	Probable	High	High	Secure embankment, build perimeter trench and berms. Monitor water level in embankment. Recovery	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
								boreholes if necessary.	
POSITION OF TSF ON APPROPRIATE BEDROCK LITHOLOGY	Positive: Possible neutralisation of any AMD by interaction with nonacid producing and buffering properties of lithology underlying the TSF.	Local	Long term	Medium	Probable	High	High	Positioning of the TSF on marble – calcsilicate lithology allows interaction and neutralization of any effluent emanating from the TSF.	Low
PERIMETER TRENCH	Negative: Contaminate surface runoff with effluent in trench	Local	Short term	Medium	Probable	High	High	Protect trench from surface water runoff by diversion with berms.	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
ROM STOCKPILE	Negative: Formation of AMD and contaminate surface / ground water	Local	Long term	Medium	Probable	High	Medium	Divert surface runoff infiltration with berms, peripheral trench to capture effluent.	Low
WASTE ROCK STOCKPILE	Negative: Formation of AMD and contaminate surface / ground water	Local	Long term	Medium	Probable	High	High	Divert surface runoff infiltration with berms, peripheral trench to capture effluent.	Low
WASTE WATER	Negative: Waste water disposal to natural environment	Local	Long term	Low	Probable	Moderate	Medium	Waste water disposed through evaporation.	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
LOCAL WATER SUPPLY	Negative: Possible loss of water supply	Local	Long duration	Low	Low	High	Low	Water for mine sourced from outside the area.	Low
DECOMMISSIONING PHASE									
CONTAMINATION AND RISK AFTER CLOSURE FROM MINE PIT	Negative: Acid mine drainage and formation of acidic pool	Local	Permanent	Medium	High	High	Medium	Addition of neutralizing material to pit. Cordoning of mine pit.	Low
CONTAMINATION AFTER CLOSURE OF TSF	Negative: Infiltration of rainwater and formation of AMD	Local	Permanent	Medium	Moderate	Moderate	Medium	Grading of TSF surface to prevent ponding of water. Seal TSF surface, place soil layer. Introduce vegetation cover.	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
TAILINGS STORAGE FACILITY STABILITY	Negative: Erosion and exposure of tailings	Local	Permanent	Medium	Moderate		Medium	Secure embankment with resistant non-acid producing material	Low
WASTE ROCK STOCKPILE	Negative: Infiltration of rainwater and formation of AMD	Local	Permanent	Medium	Moderate	High	Medium	Grading of stockpile surface to prevent ponding of water. Seal TSF surface, place soil layer. Introduce vegetation cover.	Low

7.3.3 Impact on fauna and flora

- ***Description***

Although the project area is severely bush encroached and could benefit from land clearing, some valuable trees also occur in the area. These species play an important role in the landscape as they provide greater girth for hole-nesting birds and animals, their roots extend to greater depth so they play an important role in cycling of nutrients to the surface, and their taller height is more attractive for nesting birds that look for places with least disturbance. Therefore, their loss could have a significant impact on the ecological functioning of the surrounding ecosystems (Pallett, 2014).

The impacts of powerline structures on bird species, particularly in the area surrounding the Etosha Pans, have been well documented. Mortalities through the collision of birds with conductors and earth wires are especially significant amongst larger bird species such as eagles, vultures and bustards. According to Pallett (2014), these species have a high momentum when flying and relatively poor manoeuvrability to avoid unexpected obstacles in the air predisposes them to this problem. According to ongoing research done by Pallett bustards are one of the large bird species most frequently killed by power lines in Namibia. The birds usually fly into a wire, breaking one or more bones in the wing or the body, fall to the ground and die either immediately or within the next few days from being completely handicapped.

Because of the scarcity of open water sources in Namibia, many bird species are attracted to any source of open water, including farm reservoirs. It is therefore likely that birds will also be attracted to the open pit, should it contain open water. Raptors are one of the species that are prone to drowning in steep-sided farm reservoirs (Pallett, 2014). After closure, the mine pit will remain and will contain standing water. The quality of the water is likely to be acidic with high sulphates, iron and possibly mobilised heavy metals (as sulphides in the quartzite will oxidise). The following applies to the effect on birds:

- The pit will have steep sides and no gradual shallow entrance to the water, so will not host any emergent vegetation such as sedges and reeds. For these reasons it will not be attractive to wetland birds, which like places to wade around in shallow water, and sandy banks to rest on.
- The water is likely to be lifeless, which makes it less desirable for wetland birds.
- It is possible that small locally common birds, such as starlings and doves, will drink from the sides of the pit, and swallows and swifts will do the same by their habit of swooping over the surface and taking quick sips as they pass. If the water is acidic or toxic then they could be poisoned by drinking it.

A likely consequence of more people coming in to the area and increased vehicle traffic is that opportunistic poaching and collecting of animals will occur. According to Pallett (2014), the following species are possibly at risk (Table 7-7):

Table 7-7: Fauna species potentially at risk of being poached or collected

SPECIES	DESCRIPTION OF POSSIBLE RISK
Ruppell's parrots	Robbing of nests for nestlings that go into the illegal parrot trade
Tortoises	Picked up for 'the pot' or kept as pets (which usually kills them, and certainly removes them from the natural breeding pool) whenever they are encountered.
Snakes and leguaans	Killed on sight, even if they are harmless species.
Antelope such as steenbok and kudu, warthogs, aardvark	May suffer illegal poaching.

A concern raised during the public participation period relates to the effect of the above-ground pipeline on the migration of animals across the private road. Since the pipeline will be 150 mm in diameter and placed on pedestals above ground, it is expected that smaller animals and reptiles will be able to freely move under the pipeline, whilst being low enough for bigger animals (such as small antelopes) to move over it.

Pallett (2014) concluded that overall it is expected that the project will have a relatively small negative effect on the surrounding fauna and flora, especially if the proposed mitigation measures are implemented.

- ***Mitigation***
    - ❖ Unnecessary land clearing should be prevented. The operators of all earth working machines and bulldozers, who have the ability to clear vegetation and remove trees, should be thoroughly instructed about where this should happen and where it should not. Trees to be left in place and undisturbed, should be clearly marked (such as with hazard tape) so that they are not accidentally destroyed.
    - ❖ Where possible, removal of the taller and rarer plant species should be avoided.
    - ❖ Careful landscaping during the plant layout process should aim to retain large trees wherever possible in the mine plant, administration and parking areas.
    - ❖ Wherever possible, the mine should plant and encourage indigenous trees to replace the ones lost in the land clearing, and to enhance the working environment with pleasant surroundings.

- All reservoirs should be covered with solid sheeting or shade netting. If the reservoir must be left open, steps down the inside, or a log left floating on the surface but attached to the side, will assist any bird or other small animal to get itself out of the water.
- Water remaining in the mine pit after mine closure should be neutralized as much as possible by the addition of crushed carbonate rocks, as mentioned above, so that it is less harmful to the local birds.
- Any perpetrator (guilty of illegal poaching) should be quickly and strictly punished to act as a deterrent to others. Thorough security around the mine site and construction activities is required.

- ***Summary***

The table below provides a summary of the potential impacts related to fauna and flora (Table 7-8):

Table 7-8: Summary table of impact assessment of the proposed project on fauna and flora.

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
CONSTRUCTION PHASE									
CLEARING OF LAND, PARTICULARLY OF TALL TREES	Negative impact on those birds (e.g. raptors, hornbills, parrots) that nest high or in tree-holes. Aesthetic loss.	On-site	Long term	Medium	Definite	High	Medium	Where possible, avoid relatively tall and rarer trees (list of species provided) Plant trees.	Medium – Low
COLLISIONS AGAINST POWER LINES	Negative impact	On-site	Long term to permanent	Low	Highly probable but at low frequency	Low	Low	No mitigation recommended	Low
LARGE BIRDS DROWNING IN WATER RESERVOIRS	Negative impact	On-site	Long term to permanent	Medium	Highly probable	High	Medium	Cover all steep-sided reservoirs with a solid permanent 'lid'	Low or impact removed altogether

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
INCREASED HUMAN PRESENCE, RESULTING IN ILLEGAL HUNTING	Negative impact	On-site	Greatest in the short term, but probably persisting long term	Low	Distinct possibility	Medium	Low	Security, vigilance, punishment of perpetrators. Promote pride in the local fauna and flora	Unlikely to remove the problem altogether. Impact stays Low.
OPERATIONAL PHASE									
MIGRATION OF ANIMALS - ABOVEGROUND PIPELINE	Negative impact	On-site	Long term to permanent	Low	Probable	Medium	Low	No mitigation recommended	Low
BIRDS NESTING ON POWER LINE TOWERS	Negative impact	On-site	Long term to permanent	Low	Low likelihood	Medium	Low	No mitigation recommended	Low
COLLISIONS AGAINST POWER LINES	Same as in Construction phase								
DROWNINGS IN RESERVOIRS	Same as in Construction phase								

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION	MITIGATION/ ENHANCEMENT	POST-MITIGATION
ILLEGAL HUNTING	Same as in Construction phase								

7.3.4 Impact on archaeology

- ***Description***

A full description of the archaeological features in the area has been provided in Section 5.7 and although there certainly are artefacts and features of archaeological interest in the vicinity of the proposed graphite mine, none occur on the actual sites of the open pit, plant and related infrastructure and therefore the impact of the mine on the archaeological and historical features will be minimal.

- ***Summary***

The table below provides a summary of the potential impacts related to archaeology (Table 7-9):

Table 7-9: Summary table of impact assessment of the proposed project on archaeology.

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
CONSTRUCTION PHASE									
IMPACT ON LOCAL ARCHAEOLOGY AND HISTORICALLY SIGNIFICANT SITES	Negative	On site	Permanent	Low	Improbable	Medium	Low	A final site walk-over by an archaeologist at the time of bush clearance to check for the presence of artefacts.	Low

7.3.5 Impact on the socio-economic environment

- ***Description***

Apart from contributing to the national economy through taxes and royalties, as well as the direct and indirect job creation that will result from the proposed project, a number of spin-off effects are likely to cause an economic boost to the local and regional economy (Saayman, 2014).

- ❖ Meeting the demands of the project in terms of products and services needed.
- ❖ As for the operational expenditure, this will amount to N$4,822 per ton of product at full capacity of 20,000 tpa. Sustainable income for all employed at the mine and residing in the area will increase their economic prosperity and resilience and sustainable spending. In turn their spending will add to the income of others bringing with it the potential for job creation.
- ❖ The operational employees are likely to spend a large portion of their salaries on rent and goods and services in town. During the operational phase, the salaries and wages paid to the approximately 73 staff members will amount to N$17,252,285 per annum.
- ❖ The local housing industry is likely to benefit from an increased demand for housing or erven. Of late, the housing price index in Otjiwarongo has seen a growth of almost 90 % over the last six years.

The project will however also bring about some socio-economic pressures at Otjiwarongo:

- ❖ Influx of job seekers: This could add to the current unemployment rate and can further contribute to existing social ills. Otjiwarongo currently faces problems with drug abuse, especially in the schools, as well as substance abuse and high crimes rates in town.
- ❖ Pressures on service delivery: The municipality already faces a shortage of more than 3,000 available residential erven. Cumulatively, the construction phase of the Okanjande Mine and operational phase of the B2Gold mine will exert great pressure on the lack of housing in the event that construction workers be accommodated in town.
- ❖ Sewerage system and road infrastructure: Already operating at full capacity. New people to the area, whether employed or job seekers, will add to these pressures since all of them will require housing and associated services.
- ❖ Educational facilities: Already under pressure as the demand for schooling is higher than the availability thereof.

Surrounding land uses mainly include farming of cattle and game for agriculture and tourism (hunting) purposes. The importance of the latter is contained in the existence of the Ovipuka conservancy. These activities are sensitive in terms of the bio-physical and social environment. As such, mining activities may result in an impact on the land use, which could result in a change of land use. Furthermore, the surrounding land uses are solely reliant on groundwater resources; therefore, extreme care should be taken in the avoidance and possible contamination of this resource. Another ancillary impact associated with the mining activity includes the possibility of poaching. Concerns raised by neighbouring land users stipulate the possible loss of income for the tourism and agricultural industry (cattle and game) should any poaching occur. It also jeopardizes the objectives of the conservancy to not only conserve wildlife in the area but protect all farming and personal property.

When mining activities are not adequately managed, the result is degraded soils, water, and biodiversity, which are critical to the subsistence of local people. When contamination is not controlled, the cost of the contamination is transferred to other economic activities, such as agriculture. The potential health risks associated with the operation of the mine should therefore not be underestimated. Hazardous substances and wastes in water, air, and soil can have serious, negative impacts on public health. The term 'hazardous substances' is broad and includes all substances that can be harmful to people and/or the environment. Because of the quantity, concentration, or physical, chemical or infectious characteristics, hazardous substances may:

- cause or contribute to an increase of mortality or an increase in serious irreversible or incapacitating illness; or
- pose a hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

The clearance of the site represents another potential change in land use and although very few people will be able to see it, could be unsightly. Because of the mine's location amongst hills, the mine site will not be visible from Otjiwarongo, any main road, nor from any of the local farm houses. The only point from which it will be visible to the general public will be a short section of the district road D2515.

Visibility is further reduced by the distance between the mine and the road. Light refractions will bend the light so that even though some structures are visible the viewer will not be able to identify it. A possible source of visual impact may be any light source that is used at night time. During normal operations, lights will be limited so as to reduce the potential risk of insects ending up in the processing froth. However, it is very likely that light will be used during the one month mining operations. By directing the light towards the west (in effect shielding it on the eastern side of the bulb) away from viewers on the B1 and in Otjiwarongo the impact will be significantly reduced.

According to the International Association of Assessing Officers (IAAO) (2001) incomplete information on the detrimental effects of a proposed development such as the Okanjande Graphite mine may cause the property market to overreact and prices may be depressed more that what is rational. The IAAO lists the following environmental contaminants1 as of particular importance in affecting public perception and fear which may lead to a reduction in value of neighbouring properties:

- proximity to the industrial development
- air pollution
- noise pollution
- surface and groundwater pollution
- light pollution
- hazardous substances (e.g. AMD)
- visual impact

However, according to the IAAO (2001) two factors may lessen value reduction, namely the maintenance of national and international standards and the costs associated with cleanup. Therefore, by keeping within the prescribed limits of pollution and establishing funds to ensure remediation at the end of life of mine, the impact associated with value reduction of neighbouring properties is expected to be minimal.

- ***Mitigation***
  - Provisions should be made in all tender documentation and contractors agreements which will require contractors to prove the consideration of local labour.
  - Tenders and Contractors Agreements should be drafted to ensure that contractors employ Namibian nationals as part of the unskilled and semi-skilled workforce.
  - Goods and services should be sourced locally.
  - The recruitment process should be gender inclusive, i.e. qualified women should be given an equal opportunity where possible.
  - Where possible, the skills needed for operating the equipment should be transferred to Namibians instead of recruiting expatriates for the job.

[1] Any recognized physical or nonphysical environmental influence that must be considered to determine value. It may take on various forms including physical, aesthetic and perceptual (IAAO, 2001)

- Secure accreditation for in-house skills transfer which recognizes and certifies any training courses.
- Okanjande Mine should communicate their accommodation, waste management, and sewerage disposal needs to the Municipality of Otjiwarongo to identify a mutually acceptable accommodation site, which should be within townland and preferably already disturbed.
- Okanjande Mine should consider assisting the municipal initiatives in terms of health, education etc. as part of the mine's Corporate Social Responsibility plans.
- In the event of abnormal loads being transported from either South Africa or Walvis Bay to the site, the national, regional and local traffic departments should be informed and involved.
- The mine should enter into an agreement with the farmers regarding the use of the private road to the site.
- Consult with TransNamib on services needed from them during the operational phase.
- Consult with members of the Ovipuka Conservancy to ensure that the objectives of the conservancy are considered in all aspects of mine management.
- All the neighbouring land users should be informed regarding the dates and times for blasting.
- A go-to-person should be identified by the Okanjande Mine, and his/her details provided to the surrounding land users. A platform has to be created for them to submit any complaints and also receive feedback on how issues were addressed. This can be done by electing a community representative committee who can communicate issues to the go-to-person.
- Poaching should be strictly prohibited and all employees be informed of penalties involved with such misconduct. In the event of poaching by any employee, the mine and the contractor will be responsible for compensation in cash or kind.
- An HIV/AIDS policy should be adopted by the contractors and the Okanjande mine for both the construction and operational phases. Initiatives should be implemented with regards to raising awareness on HIV/AIDS.

- ***Monitoring***
  - During the construction phase, the project team should compile an annual report indicating the number of contractors used, the amounts paid to them, as well as their country of origin. Each contractor should supply information on the number of Namibians they employ.

- The Human Resources Department will keep record on the number of employees, as well as their salary scales. The amount spent on salaries will be an indication of the amount of money that will be spent in the local, regional and national economy by the employees. Reports should also be compiled on how and where operational costs were spent indicating the local, regional and national goods and services used.
- A logbook should be kept at the gate of the access road indicating the time of entrance or exit, the type of vehicle, and its destination.
- Records of communication with the surrounding land users regarding blasting activities should be communicated by the Public Relations department to the Executive Management.
- Records of complaints received from the surrounding land users, as well as feedback on how it was addressed.
- Records of compensation paid in the event of poaching should be provided to the Executive Management, as well as disciplinary actions taken by the Human Resources Department or contractor.
- The Health and Wellness Coordinators should compile health overview reports of the workforce.

- ***Summary***

The table below provides a summary of the potential impacts related to the social environment (Table 7-10):

Table 7-10: Impact assessment of the contribution to the local and national economy.

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
CONSTRUCTION PHASE									
CONTRIBUTION TO THE NAMIBIAN ECONOMY THROUGH CAPITAL EXPENDITURE	Positive	National	Temporary	Medium	Highly Probable	High	Low	Employ local labour.	Medium
SECONDARY ECONOMIC BOOST	Positive	Regional and Local	Temporary	Medium	Highly Probable	High	Low	Locals First Policy, employ local contractors and not foreigners. Encourage local spending.	Low to Medium
JOB CREATION (IF FOREIGN)	Negative, if foreigners	Local to National	Temporary	High	Highly Probable	High	Medium	Locals First Policy	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
	are used								
JOB CREATION	Positive, of locals and Namibian are used.	Local to National	Temporary	High	Improbable	High	Low	Locals First Policy	Medium
PRESSURES ON AVAILABLE SERVICES AND HOUSING FOR ON-SITE HOUSING	Negative	Local	Temporary	High	Highly Probable	High	High	Provide housing on a negotiated site	Medium to Low
PRESSURES ON AVAILABLE SERVICES AND HOUSING FOR OFF-SITE HOUSING (OTJIWARONGO)	Negative	Local	Temporary	Medium	Definite	High	Medium	Provide housing on a negotiated site	Medium to Low
INCREASED TRAFFIC ALONG	Negative	International	Temporary	Low	Definite	High	Low	Good traffic control	Very Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
ROUTES BETWEEN SA AND NAMIBIA, AND WALVIS BAY AND THE SITE								measures, communication with the local and national traffic departments when abnormal loads come in.	
CHANGE TO LAND USE ACTIVITIES OF SURROUNDING FARMERS AND HUNTING TOURISM	Negative	Local	Long term	Medium	Highly Probable	High	Medium	Implement EMP, Community Representative committee. Compensation for land as well as poaching.	Low
INFLUX AND MOBILE WORKFORCE CONTRIBUTING TO	Negative	Local to National	Permanent	High	Highly Probable	High	Medium	Awareness Raising Campaigns,	Medium-Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
SPREADING OF HIV/AIDS								Corporate Social Responsibility,	
IMPACT ON NEIGHBOURING PROPERTY VALUE	Negative	Local	Temporary	Low	Distinct possibility	Medium	Medium	Keep to national and international standards. Establish funds for cleanup and remediation upon mine closure	Low
OPERATIONAL PHASE									
SECONDARY ECONOMIC BOOST	Positive	Regional and Local	Long Term	Medium	Highly Probable	High	Low	Locals First Policy. Encourage local spending.	Low to Medium

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
CONTRIBUTION TO THE NAMIBIAN ECONOMY THROUGH TAXES AND ROYALTIES	Positive	National	Long Term	Medium	Highly Probable	High	Low	None	N/A
JOB CREATION	Positive	Local to National	Long Term	Medium	Highly Probable	High	Low	Locals First Policy	Low to Medium
INFLUX OF JOB SEEKERS AND EMPLOYED ADDING TO EXISTING PRESSURES	Negative	Local	Long Term	Medium	Highly Probable	Medium	Low	Locals First Policy, communication with local authorities, Corporate Social Responsibility	Low
INCREASED PRESSURE ON HOUSING	Negative	Local	Long Term	High	Definite	High	Medium	Locals First Policy, communication with local authorities,	Medium to Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
								Corporate Social Responsibility	
INCREASED TRAFFIC TO TOWN AND ALONG PRIVATE ROAD TO SITE	Negative	Local	Long Term	Low	Definite	High	Low	Adhere to agreement with farmers, avoid peak traffic hours in town and use of Main Road. .	Low
CHANGE TO LAND USE ACTIVITIES OF SURROUNDING FARMERS AND HUNTING TOURISM	Negative	Local	Long Term	Medium	Highly Probable	High	Medium	Implement EMP, Community Representative committee. Compensation for land as well as poaching. Collaborate with	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
								members of the Ovipuka Conservancy to ensure that conservancy objectives are considered in the management of the mine.	
IMPACT ON NEIGHBOURING PROPERTY VALUE	Negative	Local	Temporary	Low	Distinct possibility	Medium	Medium	Keep to national and international standards. Establish funds for cleanup and remediation upon mine	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
								closure	
INFLUX AND MOBILE WORKFORCE CONTRIBUTING TO SPREADING OF HIV/AIDS	Negative	Local	Permanent	High	Medium Probable	High	Medium	Awareness Raising Campaigns, Corporate Social Responsibility	Medium-Low
DECOMMISSIONING PHASE									
SECONDARY ECONOMIC BOOST	Positive	Regional and Local	Permanent	Medium	Definite	High	Low	Locals First Policy.	Low
LOSS OF TAXES AND ROYALTIES	Negative	National	Permanent	Medium	Definite	High	Low	None	N/A
RETRENCHMENT OF OPERATIONAL EMPLOYEES.	Negative	Local to National	Permanent	Medium	Definite	High	Medium to Low	Secure accreditation for in-house skills transfer which	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
								recognizes and certifies any training courses.	
CONTINUATION OF EMPLOYMENT	Positive	Local to National	Permanent	Medium	Definite	High	Low	Locals First Policy	Low to Medium
CHANGE TO LAND USE ACTIVITIES BY SURROUDNING FARMERSAND TOURISM	Positive, if landscape rehabilitation takes place	Local	Permanent	High	Definite	High	Low	Implement rehabilitation plan	Medium

7.4 Cumulative impacts

7.4.1 Description

The (Environmental Protection Agency, 1999) defines cumulative impacts as follow:

> "Cumulative impacts result when the effects of an action are added to or interact with other effects in a particular place and within a particular time. It is the combination of these effects, and any resulting environmental degradation, that should be the focus of cumulative impact analysis. While impacts can be differentiated by direct, indirect, and cumulative, the concept of cumulative impacts takes into account all disturbances since cumulative impacts result in the compounding of the effects of all actions over time. Thus the cumulative impacts of an action can be viewed as the total effects on a resource, ecosystem, or human community of that action and all other activities affecting that resource no matter what entity (federal, non-federal, or private) is taking the actions."

The potentially cumulative impacts identified with this project, are highlighted in Table 7-11. Many of these impacts have a low overall (cumulative) significance and none of the identified cumulative impacts, justify the no-go alternative. However some impacts are considered of low significance in the context of the proposed project, but when viewed in combination with the other projects (in particular mining) currently operating in the area, the significance increases.

For example, the Municipality of Otjiwarongo currently has a significant shortfall of available housing. The problem is exacerbated by the number of other mines in the area, requiring housing for their staff in town. Therefore, even though only 87 workers will be employed during the operational phase of this project (constituting a small percentage of the overall population of Otjiwarongo), the shortage should be viewed in terms of the total required by all entities in the area. This increases the significance of the potential impact.

Another example relates to the strain on road infrastructure. Because the B1 road passes through the centre of town, all traffic en route to the northern regions of Namibia are forced through the town. This means that a bottleneck is created through Otjiwarongo's main street. Despite the low number of trucks that will be transporting products to and fro the mine, the cumulative impact on the road infrastructure is expected to be more significant than if looked at separately.

Table 7-11: Cumulative impacts expected on the proposed project.

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
BIODIVERSITY									
OVERALL IMPACT OF THE PROJECT ON THE SURROUNDING BIODIVERSITY	Negative	Local	Long term - permanent	Minor effects	Highly probable	High	Low	Avoid the unnecessary removal of large tree species.	Low
CARBON FOOTPRINT									
GREENHOUSE GAS (GHG) EMISSIONS ASSOCIATED WITH THE PROJECT	Negative	International	Permanent	No local effects from greenhouse gas emissions	Definite	High confidence	None associated with GHG emissions	Impacts expected to be well below (<1%) of the international standards and guidelines.	None associated with GHG emissions

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
CONTRIBUTION OF THE PROJECT (COLLECTIVELY WITH GLOBAL EMISSIONS) TO CLIMATE CHANGE;	Negative	International	Permanent	Minor effects	Definite	High confidence	Low	Impacts expected to be well below (<1%) of the international standards and guidelines.	Low
POLLUTION									
IMPACT OF THE PROJECT ON LOCAL AIR QUALITY	Negative	Local	Long Term	Minor	Probable	Medium	Medium	Particulate emissions from the ROM stockpile and tailings storage facility should be controlled using best available practice.	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
IMPACT OF THE PROJECT ON GROUND AND SURFACE WATER RESOURCE;	Negative	Local	Permanent	Moderate effect	Improbable	High	Medium	Mine supply will not affect local groundwater sources. Divert surface water runoff with berms.	Low
NOISE IMPACT OF THE PROJECT;	Negative	Local	Short Term	No Lasting Effect	Highly probable	High	Low	All the neighbouring land users should be informed regarding the dates and times for blasting.	Low
VISUAL									
OVERALL VISUAL IMPACT OF THE	Negative	Local	Long Term	Minor	Improbable	High	Low	Because the local	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
PROJECT;								topography creates an effective visual screen, no further measures to screen the mine will be necessary.	
SOCIO-ECONOMIC									
CONTRIBUTING TO THE EXISTING TREND OF INFLUX OF JOB SEEKERS	Negative	Local	Permanent	Minor Effects	Highly probable	High	Low	Locals First Policy	Low
CONTRIBUTION TO THE NAMIBIAN ECONOMY THROUGH CAPITAL EXPENDITURE	Positive	National	Long term	Minor effect	Highly Probable	High	Low-medium	N/A	Low-medium

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
CONTRIBUTION THROUGH TAXES AND ROYALTIES	Positive	National	Long Term	Moderate Effect	Highly Probable	High	Low-Medium	N/A	Low-Medium
EMPLOYMENT CREATION DURING CONSTRUCTION AND OPERATIONAL PHASES	Positive, if locals and Namibian are used.	Local to National	Long term	Minor effects	Highly probable	High	Low-Medium	Locals First Policy	Medium
STIMULATING SECONDARY BUSINESS ACTIVITIES/ SPIN-OFF EFFECTS	Positive	Local to national	Long Term	Minor effects	Probable	High	Low	Locals First Policy, employ local contractors and not foreigners. Encourage local spending.	Low to Medium
ADDITIONAL STRAIN ON	Negative	Local	Long term	High	Definite	High	Medium	Communicatio	Low

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
HOUSING INFRASTRUCTURE								n with local authorities. Mine to provide housing.	
INFLUX AND MOBILE WORKFORCE CONTRIBUTING TO SPREADING OF HIV/AIDS	Negative	Local to National	Permanent	Low	Highly Probable	High	Medium	Awareness Raising Campaigns	Medium-Low
ROAD AND TRAFFIC									
ADDITIONAL STRAIN ON ROAD INFRASTRUCTURE	Negative	Local	Long term to permanent	High	Definite	High	High	Good traffic control measures, communication with the local and national traffic	Medium

POTENTIAL IMPACT	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	DEGREE OF CONFIDENCE	SIGNIFICANCE		
							PRE-MITIGATION/ ENHANCEMENT	MITIGATION/ ENHANCEMENT	POST-MITIGATION/ ENHANCEMENT
								departments when abnormal loads come in.	

8 Conclusions and Recommendations

This report is submitted to the Directorate of Environmental Affairs (DEA) to enable them to consider whether or not to grant authorisation to the proposed development and to assist this institution in defining the conditions for this development if it should go ahead. This aims to ensure that informed decisions are being made that contribute to an environmentally and socially sound and sustainable development.

Since the start of the initial investigations (Walmsley Environmental Consultants, 1992), leading up to the current EIA, stakeholder engagement and specialist investigations have played a significant role in defining the biophysical and social environment and for determining how the proposed development will affect them. This chapter provides an overview of the alternatives considered and the anticipated residual impacts. It also makes recommendations regarding key mitigation measures.

8.1 Consideration of Alternatives

The main reason for considering alternatives is to adhere to the mitigation hierarchy of firstly striving to avoid the impacts before considering reduction through mitigation.

8.1.1 Position of the TSF

Because of limited groundwater and the dependence of surrounding land users on the groundwater, positioning of mining components was a key consideration in the EIA. Results from the ABA studies indicated that the underlying Nosib quartzites are acid producing which means that the combination of exposure to air and application of water (through infiltration) could contribute to the creation of Acid Mine Drainage. The Swakop group, on the other hand, contains marble and calc-silicate units with low permeability. The neutralising capabilities of these rocks could ensure the long-term and safe storage of not only the tailings but also other mine components such as the waste rock stockpile and the ROM stockpile. By considering alternative locations for the key mine components (excluding the mine pit which is restricted to the ore boundaries), potential groundwater pollution could largely be avoided. Proposed mitigation measures in this regard, are expected to reduce the impact even further. The process of avoidance and consideration of alternative locations resulted in the final mine layout plan (Figure 2-1) that has been the product and subject of this EIA.

8.1.2 Tailings disposal

How tailings are disposed of is one of the key considerations that determine whether the proposed mining project is environmentally acceptable or not. The long term objective of tailings disposal and management is to prevent the mobilization and release of toxic constituents into the environment. In some circumstances dry tailings disposal poses the lowest risk and are therefore the environmentally preferred choice. However, wet tailings disposal are by far the most commonly used option, probably because of the lower capital expenditure required. Throughout this EIA, the potential risks associated with each of the tailings disposal options (i.e. wet or dry disposal) were considered. A dewatered wet tailings disposal (still classified as wet tailings) was proposed by the client and assessed along with a dry tailings option by the specialists appointed in the various fields.

Most of the specialist studies were neutral in terms of the preferred alternative and none of them indicated a fatal flaw in either the wet or dry option. The fully wet disposal option is discarded due to the large water demand and increased risk of seepage and contamination. The limited availability of water (and therefore requirement to recycle) and increased risk of underground seepage makes a dry TSF more appropriate. A practical compromise is therefore constituted by the dewatered wet tailing option where 79% of the water can be recovered.

The following recommendations are made by the specialists in terms of the dewatered wet tailings disposal option:

- Close monitoring of water levels in the embankments and in the basement rocks is to be carried out with provision for seepage recovery in place.
- The high evaporation rate is expected to reduce the amount of water in the tailings but can also result in cracking and enhance vertical permeability. The tailings are to be kept in a saturated condition until the surface is neutralized and covered.
- Presence of yet unmapped fault / fracture or contact zones within the marble calcsilicate unit could result in increased seepage rates. Monitoring of groundwater levels and water balance is required together with the installation of recovery boreholes.
- The TSF should be constructed according to the design specifications where the tow-wall or starter wall would serve as a windbreak on the windward side of the TSF. The dormant areas should be vegetated and continually re-vegetated to minimize windblown dust emissions from the surface areas. The beach areas should be kept moist to ensure minimum erosion potential.

- Measures to reduce the acidity and the ponding of excess water, or to cover the wetted area, are recommended.

8.1.3 Accommodation of the workforce during construction

Another consideration related to the accommodation of the workforce on site or off site (Otjiwarongo). Three key risks contributed to the recommendation that workers should be accommodated off site: No services are available at the mine site, accommodation of 300 workers on site could pose significant environmental impacts and the risks posed by the uncontrolled movement of people on the surrounding farms that may lead to poaching and theft. Although on-site accommodation could constitute an option subject to the provision of adequate infrastructure and environmental control by the project developers, surrounding land users have voiced their concern and objection towards this option. The matter would represent one aspect for regular environmental reporting. Based on the findings of the specialist study, it is therefore recommended that the proponent come to an agreement with the local municipal authority on a suitable town lands area preferably already disturbed. Should no such area be available, a suitable area is to be negotiated with the municipality which will consider neighbouring land users and land owners.

8.2 Synopsis of the Key Impacts

While the consideration of alternatives resulted in the avoidance of some impacts, residual impacts that cannot be avoided still remain. The key ecological and social impacts related to the proposed construction and operation of the proposed mine can be summarised as follows:

- Impact on air quality, human and animal health and vegetation: Dispersion modelling results indicated that dust fallout and elevated PM and NO2 levels occur mostly at the mine site. The main source of SO2 emissions is the oxidation of sulphide with a large uncertainty around the emission strengths. Based on this, the degree of confidence is low resulting in Medium significance. Using low sulphur fuels in the vehicles, equipment and drier, the significance can reduce further to Low. Since the nearest dwellings are located some distance away from the mine, the significance of these emissions is expected to be low.
- Impact on groundwater and surface water hydrology: Sulphide in the ore and waste rock could result in groundwater contamination due to the formation of Acid Mine Drainage from tailings and stockpiles. The position of the TSF was therefore moved so that it is located on the carbonate rich rocks of the Swakop Group. The deep water levels and low hydraulic conductivity associated with these rocks together with the limited water in the dewatered tailings and addition

of neutralising agents to the tailings adds to the security of the groundwater. Low inflow rates are estimated to the mine pit that could require neutralisation if found to be acidic. The general impact of the mine is seen to be of low significance if the recommended mitigation measures are implemented.

- Impact on fauna and flora: The most significant impact is the unavoidable land clearing that must be done at the start of the project. However careful landscaping and routing infrastructures around major trees, and revegetation once the mine is established can reduce the significance of the impact to acceptable levels. The initial concern regarding bird collisions with the new power line were found to be of low significance and no mitigatory actions are recommended. Overall the impact of the proposed project is expected to be of low significance.
- Impact of the project on the socio-economic environment: The project is expected to make several positive contributions the economy of Otjiwarongo and Namibia and cumulatively, will contribute to Namibia reaching its Vision 2030 goals. However, some negative impacts such as the expected influx of people to town and the associated pressures of this on the town's infrastructure and services require the implementation of the recommended mitigation measures. Nevertheless, it is concluded that the positive impacts resulting from this proposed project will outweigh the negative ones.

8.3 Key Recommendations

8.3.1 The TSF

According to Namib Hydrosearch (2014) the performance of the seepage control measures are to be evaluated and monitored with the wet disposal option. The indication of higher seepage rates than expected would require the following actions:

- "Measures to contain and recovery of water from the TSF cells during the start-up stages.
- Installation of recovery boreholes for retrieval of the effluent without affecting downstream groundwater users. Recovery boreholes may be required if seepage through or below the embankments is recorded with development of a phreatic water surface in the tailings.
- If monitoring of water levels and seepage quality indicates leakage through the bedrock underlying the TSF, the possibility shifting to dry tailing disposal has to be considered."

These recommendations apply if all the sulphides are disposed in the TSF and are not removed during rutile recovery. Removal of the sulphides will make the tailings more inert.

The type of TSF cover (seal) design will depend on the monitoring information and experience gained during the operation stage of the mine. However, placement of a low permeability seal on the TSF is the preferred measure. This method limits the possibility of rainwater infiltration and salt accumulation at surface by capillary action. Large quantity of clay rich material is required for the proposed 1m thick cover that may not be available locally. Other material such as compacted calcrete is to be evaluated.

Various methods exist that can reduce the impact of wind erosion. If a seal is placed on the TSF, it will need to be covered with a thin layer of topsoil to allow for the re-establishment of vegetation. Alternatively, rock cladding can be used on top of the seal. Any approach that either binds the particles together or make them more resistant to wind erosion, or reduce to the force of the wind will result in a reduction in windblown dust emissions (Airshed Planning Professionals, 2014).

8.3.2 The RWD

The RWD needs to be lined as suggested in Gecko (2014) with strip drains to prevent seepage. Steps will also have to be taken to minimise the retention time in the RWD and to pump this water as a priority for use in the plant. The RWD will be designed to accommodate storm water and to contain surface runoff from the TSF. Dilution of the effluent to a significant level is expected under these conditions.

8.3.3 Waste rock stockpile

"Diversion of stormwater drainage from the stockpiles with berms and peripheral trenches to collect seepage water and close monitoring is recommended. The addition of pulverised limestone (marble) to the stockpile to raise the pH and precipitate metals in the long term is recommended. On closure of the mine the stock piles are to be graded to encourage runoff and limit infiltration. The surface is to be covered with soil and vegetated. The protective berms diverting surface flow are to remain to avoid any erosion of the soil cover (Namib Hydrosearch, 2014)."

8.3.4 ROM stockpile

"Diversion of storm water drainage with berms and peripheral trenches to collect seepage water and close monitoring is recommended. On closure of the mine the stock piles are to be graded to encourage runoff and limit infiltration. The surface is to be covered with soil and vegetated. The protective berms diverting surface flow are to remain to avoid any erosion of the soil cover (Namib Hydrosearch, 2014)."

8.3.5 Workforce

A 'Locals First' policy should be adopted. The hierarchy to be followed starts at Otjiwarongo, then the region and then only can candidates be considered at a national level. During the construction phase, it is highly recommended that locals and Namibians be used rather than a foreign contractor. Not only will this contribute to the economy and job creation, but also limit the potential for the spreading of disease and impact on local housing and services in Otjiwarongo.

Construction workers should be accommodated in town, and not on-site. This will limit security risks such as poaching, limit the need for the construction of infrastructure for services on–site and encourage local spending in town.

8.4 Final Conclusion

The impacts associated with the proposed graphite mine can be reduced to acceptable measures. However, it is important that the measures provided in the EMP (APPENDIX I) and associated management plans are implemented and monitored.

It is therefore recommended that the project receive Environmental Clearance, provided that the EMP be implemented.

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