Metago
Environmental Engineers (Pty) Ltd

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE PROPOSED EXPANSION PROJECT AT LANGER HEINRICH MINE

Prepared For

Langer Heinrich Uranium (Pty) Limited

METAGO PROJECT NUMBER: L016-01

REPORT NO. 2

August 2009

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Author	B Stobart
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METAGO ENVIRONMENTAL ENGINEERS (PTY) LTD

Physical Address:
Metago House
Fourways Manor Office Park
Corner Roos and Macbeth Streets
Fourways
Johannesburg
South Africa

Postal Address:
P O Box 1596
Cramerview
2060

Tel: +27 (011) 467-0945

Fax: +27 (011) 467-0978

E-mail: brandon@metago.co.za

Web: www.metago.co.za

ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE PROPOSED EXPANSION PROJECT AT LANGER HEINRICH MINE

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1. INTRODUCTION

1.1. INTRODUCTION TO THE PROPOSED PROJECT

Langer Heinrich Uranium (Pty) Ltd (LHU), a wholly owned subsidiary of Paladin Energy Ltd, owns and operates the Langer Heinrich uranium mine situated approximately 90km east of Swakopmund in the Namib Naukluft National Park. The regional and local setting of the ML is illustrated in Figure 1-1 and Figure 1-2. The mine operates within a specified area in terms of mining licence 140 (ML). From an environmental authorisation and management perspective the following points are relevant to the current activities within the ML:

- the original EIA (Softchem, 2005) was submitted for authorisation in 2005 and a related environmental clearance certificate was issued in 2005;
- the original EMP (Speiser, 2005) was submitted and approved in 2006. The related pro forma environmental contract between LHU, the Ministry of Environment and Tourism (MET) and the Ministry of Mines and Energy (MME) was signed in 2006;
- the EMP was amended (LHU, 2008) to cater for expansion activities and approved in 2008 by MET; and
- LHU has implemented an environmental management system that complies with the requirements of the ISO14001 (International Organisation for Standardisation, 2004). The associated certification was received from Lloyds Register Quality Assurance in February 2009.

LHU proposes to expand its current operations at the mine in order to increase the uranium oxide production from 3.7 million pounds per annum to between 5 and 10 million pounds per annum. The main components of the expansion project include: an increase in the rate of mining, a new satellite mine workshop, the expansion of the existing processing plant, a new satellite crushing plant, a heap leach pad, modifications to tailings management, a temporary contractor's camp, additional power supply to the water abstraction boreholes located in the Swakop River, and additional support infrastructure and services. The expansion project is referred to as "the project".

1.2. INTRODUCTION TO THE ENVIRONMENTAL IMPACT ASSESSMENT

Prior to the commencement of the expansion project, authorisation is required on the basis of an environmental impact assessment (EIA) report. On request of the Ministry of Environment and Tourism (MET): Directorate of Environmental Affairs (DEA), the draft EIA regulations (April 2009) have been used as a guideline for this EIA process and report. To supplement this, reference has also been made to the Namibian Environmental Assessment Policy (1995).

The required components of the EIA report are included in Table 1-1:

TABLE 1-1: REQUIREMENTS FOR EIA REPORTS

Draft EIA Regulation requirement	Policy requirements	Reference in the EIA report
Details of the environmental assessment practitioner (EAP) that compiled the report and the expertise of the EAP to carry out the EIA.	List of compilers.	Section 1.2.2.
Detailed description of the proposed activity.	Project proposal.	Section 6.
Description of the property on which the activity is to be undertaken and the location of the activity on that property.	The affected environment.	Section 3 and 4, and Figure 6-1.
Description of the environment that may be affected by the activity.		Section 3 and 4.
Description of the need and desirability of the proposed activity and identified potential alternatives to the proposed activity, including advantages and disadvantages that the proposed activity or alternatives may have on the environment and any affected community.		Section 5.
Description and comparative assessment of alternatives identified during the EIA.		Section 5.
Indication of the methodology used in determining the significance of the potential environmental impacts.		Section 7.
Description of the manner in which the physical, biological, social, economic and cultural aspects of the environment may be affected by the proposed activity.		Section 7.
Description of the environmental issues that were identified during the EIA, an assessment of the significance of each issue and an indication of the extent to which the issue could be addressed by the adoption of mitigation measures.		Section 7.
The assessment of each impact must include: cumulative impacts, and an assessment of the nature, extent, duration, probability, reversibility, irreplaceable loss of resources and mitigation components of the impact.	The assessment and evaluation.	Section 7.
List of persons, organisations and organs of state that were registered as interested and affected parties (IAPs).		Section 2 and Appendix B.
A summary of comments received from and a summary of issues raised by IAPs, the date of receipt of these comments and the response of the EAP		Appendix D.

Draft EIA Regulation requirement	**Policy requirements**	**Reference in the EIA report**
to the comments.		
Copies of any representations, objections and comments received from IAPs.		Appendix C
Summary of the findings and recommendations of any specialist report		Section 7. Also see specialist reports attached between Appendix F and Appendix P.
Description of any assumptions, uncertainties and knowledge gaps	Assumptions and limitations. Incomplete or unavailable information.	Integrated into various sections of the report. Also see specialist reports attached between Appendix F and Appendix P.
An opinion on whether the activity must be authorised and related conditions	Conclusion and recommendations.	Section 8.
An EIA statement containing a summary of the key findings of the EIA and a comparative assessment of positive and negative implications of the proposed activity and identified alternatives		Section 5.2 and Section 8.
A draft environmental management plan (EMP)	Management plan Monitoring programme Audit proposal.	Appendix Q.
Financial guarantee as security for cost of rehabilitation, decommissioning or reclamation		Financial provision is managed internally by LHU on the company balance sheet.
Copies of specialist reports		Attached between Appendix F and Appendix P.
Other information required by the competent authority		Not applicable
	Executive summary Contents page Introduction.	See EIA report before this table.
	Terms of reference.	Appendix C
	Approach to study.	Section 1.2.1
	Administrative, legal and Policy requirements.	Sections 1 and 9
	Environmental contract.	Appendix A
	Definitions of technical terms. Acknowledgements.	Integrated into various sections of the EIA report and included in the various specialist reports
	Appendices.	Attached.

FIGURE 1-1: REGIONAL SETTING

FIGURE 1-2: LOCAL SETTING

1.2.1. EIA APPROACH AND PROCESS

A summary of the approach and key steps in the EIA process and corresponding activities are outlined in Table 1-2.

TABLE 1-2: EIA PROCESS

Objectives	Corresponding activities
Project initiation/screening phase (January – February 2009)	
• Notify the decision making authority of the proposed project. • Initiate the environmental impact assessment process.	• Internal screening meetings between Metago and LHU technical team to discuss the project requirements and identify environmental issues and to determine legal requirements. • Meeting with the Ministry of Environment and Tourism (MET): Directorate of Environmental Affairs (DEA). • Written notification submitted to MET (26 February 2009).
Scoping phase (February – April 2009)	
• Identify interested and/or affected parties (IAPs) and involve them in the scoping process through information sharing. • Identify potential environmental issues associated with the proposed project. • Consider alternatives. • Identify any fatal flaws. • Determine the terms of reference for additional assessment work.	• Notify government authorities and IAPs of the project and EIA process (telephone calls, e-mails, faxes, distribution of background information, newspaper advertisements and site notices). • Scoping meetings with authorities, and IAPs (10 – 12 March 2009). • Compilation of scoping report (Metago 2009). • Distribute scoping report to relevant authorities and IAPs for review (April 2009). • Forward finalised scoping report and IAPs comments to MET for review (May 2009). • MET verbally instructed Metago to continue in accordance with the terms of reference (June 2009).
EIA/EMP phase (March to October 2009)	
• Provide a detailed description of the potentially affected environment. • Assessment of potential environmental impacts. • Design requirements and management and mitigation measures. • Receive feedback on EIA and EMP.	• Investigations by technical project team and appointed specialists – baseline field work and assessment. • Compilation of draft EIA and EMP reports. • Distribute EIA and EMP reports to independent reviewer, authorities and IAPs for review (August 2009). The review period is 30 days. • Open days to facilitate review and comment (September 2009). • Forward final EIA and EMP reports and IAPs comments to MET for review (October 2009). • Circulate the record of decision from MET to all IAPs registered on the public involvement database.

1.2.2. EIA TEAM

Metago Environmental Engineers (Pty) Ltd (Metago) is the independent firm of consultants that has been appointed by LHU to undertake the environmental impact assessment and related processes. Brandon Stobart (project manager) has ten years of relevant experience and is certified with the Certification Board for Environmental Assessment Practitioners of South Africa (EAPSA) as an Environmental

Assessment Practitioner (EAP). Colleen Parkins (project review) has twelve years of relevant experience and is registered with the South African Council for Natural Scientific Professions (SACNSP) as a professional natural scientist (*PrSciNat*). Fiona Parkin (the project assistant) has three years of relevant experience. The relevant curriculum vitae documentation is attached in Appendix E.

The environmental project team is outlined in Table 1-3.

TABLE 1-3: ENVIRONMENTAL PROJECT TEAM

Team	Name	Designation	Tasks and roles	Company
EIA project leader	Werner Petrick	LHU environmental specialist	Responsible for the interface between LHU and the environmental team, and for ensuring implementation of the EIA outcomes	LHU
EIA Project management	Brandon Stobart	Project manager	Management of the process, team members and other stakeholders. Report compilation	Metago
	Fiona Parkin	Project assistant		
	Colleen Parkins	Project review	Report and process review.	
Specialist investigations	Hanlie Liebenberg-Enslin	Air quality	Air quality impact assessment	Airshed Planning Professionals
	Ian Jones	Soils and land capability specialist	Soils and land capability assessment	Earth Science Solutions
	Graham Young	Visual specialist	Visual impact assessment	Newtown Landscape Architects
	John Kinahan	Archaeologist	Heritage resource assessment	Quaternary Research Services
	Marie Hoadley	Social specialist	Social impact assessment	Independent consultant
	Gerrie Muller and Eon Reyneke	Economist	Economic impact assessment	Metago Strategy4Good
	Gerhard Liebenberg and Gert De Beer	Radiological specialists	Radiological impact assessment	Nuclear Energy Corporation of South Africa
	Michelle Yates	Co-ordination	In-country public participation co-ordination and management of biodiversity team	Independent consultant
	Marianne Strohbach	Biodiversity	Vegetation assessment	Independent consultant
	Michelle Yates			
	Joh Henschel		Vertebrate assessment	Gobabeb Desert Research Foundation
	John Irish		Invertebrate assessment	
	Arnold Bittner	Water scientist	Groundwater assessment	Bittner Water Consult
	Marcus Zinglemann			
	Gordon MacPhail	Engineer	Tailings and Hydrology assessment	Metago

1.2.3. CONTACT DETAILS FOR RESPONSIBLE LHU PARTIES

The LHU contact details for the project are included in Table 1-4.

TABLE 1-4: LHU CONTACT DETAILS

Title	**Environmental specialist**	**General manager**
Name	Mr Werner Petrick	Mr Wyatt Buck
Postal address	PO Box 156 Swakopmund Namibia	PO Box 156 Swakopmund Namibia
Telephone number	+264 644106238	+264 64410 6201
Facsimile number	+264 644106299	+264 64410 6299

2. PUBLIC CONSULTATION

The range of environmental issues to be considered in the EIA has been given specific context and focus through consultation with authorities and IAPs. Included below is a summary of the people consulted, the process that was followed, and the issues that have been identified.

2.1. AUTHORITIES AND INTERESTED AND AFFECTED PARTIES (IAPS)

The following authorities and IAPs are involved in the EIA process:

- **National authorities:**
  - Ministry of Environment and Tourism (MET);
    - Directorate of Environmental Affairs
    - Directorate of Parks and Wildlife;
  - National Heritage Council of Namibia;
  - Ministry of Mines and Energy (MME);
  - Ministry of Agriculture, Water and Forestry (MAWF);
  - Ministry of Health and Social Services (MHSS);
  - Ministry of Labour and Social Welfare; and
  - Ministry of Works, Transport and Communications.
- **IAPs:**
  - farmers and landowners;
  - surrounding mines and industries;
  - non-government organisations and associations;
  - local authorities (Erongo Regional Council, Swakopmund and Walvis Bay Municipalities);
  - parastatals such as NamWater and NamPower; and
  - any other people/entities that choose to register as IAPs.

2.2. STEPS IN THE CONSULTATION PROCESS

Table 2-1 sets out the steps in the consultation process that has been conducted to date:

TABLE 2-1: CONSULTATION PROCESS WITH IAPS AND AUTHORITIES

TASK	DESCRIPTION	DATE
Notification - regulatory authorities and IAPs		
Pre-notification meeting with MET	A pre-notification meeting was held with the MET. Minutes of the meeting are included in Appendix A.	03 February 2009
Written notification to MET	Formal written notification was submitted to the MET. A copy of the notification letter is attached in Appendix A.	24 February 2009
IAP identification	LHU's existing stakeholder database was used as a starting point to identify IAPs. The database was updated to include additional IAPs that were identified during the scoping and EIA as required. A copy of the IAP database is attached in Appendix B.	February 2009

TASK	DESCRIPTION	DATE
Distribution of background information document (BID)	BIDs were distributed via email to all IAPs on the project's public participation database and were available at the scoping meetings. A copy of the BID is attached in Appendix C. The purpose of the BID was to inform IAPs and authorities about the proposed project, the EIA process, possible environmental impacts and means of inputting into the EIA process. Attached to the BID was a registration and response form, which provided IAPs with an opportunity to submit their names, contact details and comments on the project.	February – March 2009
Site notices	Four laminated site notices were placed at key conspicuous positions in the proposed project area. Copies of the site notices and photographs of the places where site notices were displayed are attached in Appendix C.	February 2009
Newspaper advertisements	Three block advertisements were placed in two national newspapers (The Namibian and The Republikein) and one local newspaper (Namib Times). Copies of the advertisements are attached in Appendix C.	February 2009
Scoping stage meetings and submission of comments		
Scoping meetings	Three public scoping meetings were arranged in Windhoek, Walvis Bay and Swakopmund respectively. The same project information was presented at all three meetings. Minutes of the meetings are attached in Appendix C. As part of some of the specialist investigation work focussed meetings were held with stakeholders. Related issues and records are included in the relevant specialist reports as attached to the EIA.	10 – 12 March 2009
Review of scoping report		
IAPs and authorities (excluding MET) review of scoping report	Copies of the scoping report were made available for review at the following places: MET library and Windhoek public library, Walvis Bay public library, Swakopmund public library and the Langer Heinrich town office. Electronic copies of the report were made available on request (on a CD). Summaries of the scoping report were distributed to all authorities and IAPs that are registered on the project's public involvement database via post and/or e-mail. Initially, authorities and IAPs were given 30 days to review the scoping report and submit comments in writing to Metago. The closing date for comments was 15 May 2009. As additional IAPs were identified the comment period was extended to allow the additional parties the opportunity to comment.	From 16 April 2009
MET review of scoping report	A copy of the final scoping report, including authority and IAP review comments that were received to date, was forwarded to MET on completion of the public review process.	May to June 2009

TASK	DESCRIPTION	DATE
Review of EIA and EMP reports		
IAPs and authorities (excluding MET) review of EIA and EMP report	Copies of the EIA and EMP reports have been made available for review at the following places: MET library (Windhoek) and National library of Namibia (Windhoek), Walvis Bay public library, Swakopmund public library and the Langer Heinrich town office. Electronic copies of the report were made available on request (on a CD). Summaries of the EIA and EMP report have been distributed to all authorities and IAPs that are registered on the project's public involvement database via post and/or e-mail. A 30 day review period applies. In addition, the report was submitted for external review to the SAIEA in this period.	August to September 2009
Public open days	In order to facilitate the review and final comment on the EIA and EMP, 2 open days will be held in September in Windhoek and Swakopmund.	September 2009
MET review of EIA and EMP report	A copy of the final EIA and EMP report, including all review comments, will be forwarded to MET for decision.	October 2009

2.2.1. SUMMARY OF ISSUES RAISED

A description of issues that have been raised to date by authorities and IAPs is given in Appendix D. Issues raised pertain to:

- EIA procedural issues;
- technical/project related issues;
- decommissioning and closure;
- water supply;
- power supply;
- soils;
- biodiversity;
- heritage resources;
- groundwater;
- air quality;
- geology;
- radioactivity aspects;
- noise;
- visual;
- transport; and
- socio-economic.

3. DESCRIPTION OF THE CURRENT ENVIRONMENT

The information provided in this chapter must be read in the context of an operating uranium mine that is situated within the boundaries of an approved ML and within a unique area of the Namib Naukluft Park.

3.1. GEOLOGY

Information in this section was sourced from LHU and from the groundwater specialist study (BIWAC 2009) included in Appendix J.

The ML is situated in the Damara Belt syncline. The oldest beds consist of psammitic rocks of the Nosib Group overlain by several thousand metres of politic rocks of the Swakop Group and the Khomas Subgroup all of Proterozoic Age. Weathering and erosion of uraniferous granites are thought to be the source of uranium that precipitated to form secondary deposits such as Langer Heinrich. The lowermost rocks of the Damara Sequence form the Langer Heinrich Mountain anticline. Overlying these quartzites are schists comprised of interbedded fine-grained metapelite, metagreywacke and calcsilicate beds.

The uraniferous fluvatile sediments in the Langer Heinrich Formation, were deposited under flash-flood conditions in deep palaeochannels. The sediments of the Langer Heinrich deposit consist mainly of angular clastic basement debris forming alternating bands of conglomerate, gravel, and clay, the coarser fractions predominating. Carnotite is the main uranium mineral, occuring interstitially and bounding larger coarser clasts, and has maximum development in zones of high porosity.

Depths to the base of the palaeochannel are variable and sedimentary thicknesses up to 150m have been recorded. Grades tend be be highest in a central core zone with uranium distribution totally irregular and discontinous.

A conceptual geological cross section of the five identified layers is presented in Table 3-1. More detail on the geological cross sections within the ML are provided in the groundwater specialist study (BIWAC 2009).

TABLE 3-1: CONCEPTUAL GEOLOGICAL CROSS SECTION OF MINING ZONE

Layers	Geology	Hydraulic Properties	Original state and properties	Interpretation for groundwater model	Layer Thickness
Layer 1	Quaternary sediments	Unconfined	Recent channel, sediments, dry	Can be rewetted by floods, perched water table, drainage on the surface of layer L2a, percolation into the unsaturated layer L2a.	Up to 8m thick
Layer 2a	Tertiary sediments, calcrete	Partially and temporarily confining layer	Dry, confines 3rd layer	Layer 2a - Partially kartified.	Up to 14m thick

Layers	Geology	Hydraulic Properties	Original state and properties	Interpretation for groundwater model	Layer Thickness
Layer 2b	and/or clay			Layer 2b - Less permeable sublayer, can be rewetted.	Up to 20m thick
Layer 3	Tertiary sediments, gravel with clay	Partially confined layer	Fully saturated, confined flow	Saturated, recharged by basement and by percolation depending on pressure gradients.	Up to 44m thick
Layer 4	Basement rock	Mainly low hydraulic conductivity	Inactive	Active recharge on basin, interacting with layer L3.	Greater than 150m in thickness

.

The results of geophysics and borehole log analysis has revealed a number of inferred faults within the ML. These are shown as geological features on Figure 3-1.

FIGURE 3-1: TOPOGRAPHY, GEOLOGY AND BOREHOLES

3.2. CLIMATE

Information in this section was sourced from the on-site LHU weather station and the hydrology and air specialist studies included in Appendix F (Metago 2008) and Appendix G (Airshed 2009) respectively.

3.2.1. REGIONAL CLIMATE

Although the ML is situated in the arid Namib Desert it is approximately 90km from the coast. Given this, the climate is influenced by both the interior desert and the Atlantic Ocean.

3.2.2. RAINFALL

Annual rainfall in the relevant region consistently increases with distance from the coast. Both LHU and Rossing mine are situated in a belt that receives an average of less than 100mm of rain per annum. The recorded rainfall data for both of these mines indicates that rainfall events are uncommon with the chance of rain on any given day being calculated at less than 5%. The recorded annual rainfall ranges from less than 5mm to more than 100mm. The wetter months are January, February, March and April. The drier months are June, July and August. In dry periods, the region can experience periods of up to a year without any rainfall. Flash flooding has also been known to occur due to significant rainfall events. The maximum single recorded rainfall event in the region is 45mm (recorded at Rossing in 1995).

In addition, it must be noted that LHU is within the coastal fog belt. Fog events provide an important source of moisture to the ecosystem functionality.

3.2.3. TEMPERATURE

The recorded annual average temperate is 24˚C. The typical range is from 5˚C to 45˚C. The variation between summer and winter months is approximately 7˚C for both maximum and minimum temperatures.

3.2.4. WIND

Wind roses for average day and night wind conditions are shown in Figure 3-2. The predominant daytime wind is from the northwest, west and south west. The predominant night time wind is from the southeast. In general, the stronger winds are from the eastern sector and are associated with speeds in excess of 8m/s. The seasonal variability in the wind data is shown in Figure 3-3. During the spring and summer months, strong winds of more than 8m/s dominate from the westerly sector with infrequent winds from the other sectors. During the autumn and winter months, strong winds of more than 8m/s dominate from the easterly sector with some westerly winds still occurring. It is during the winter months that the highest wind speeds are recorded and these are associated with the "east winds". The highest recorded wind speed at LHU is 17.2m/s.

FIGURE 3-2: AVERAGE DAY AND NIGHT WIND ROSES

FIGURE 3-3: SEASONAL WIND ROSES

3.2.5. EVAPORATION

Average evaporation exceeds average rainfall with the average daily evaporation being measured at 7mm.

3.3. TOPOGRAPHY

The ML is located on the eastern edge of the desert zone, in the northerly part of the Namib Naukluft Park. The project area is situated within and beneath a 1 – 2 km wide, flat-bottomed valley, between the Langer Heinrich Mountains to the north (1 152m above mean sea level [amsl]) and the Schiefer Mountains to the south (883m amsl). The valley is 710 m amsl at its high point and descends gradually towards the west to an elevation of 550 m amsl. (see Figure 3-1).

3.4. SOIL

Information in this section was sourced from the soil specialist study included in Appendix H (ESS 2009).

3.4.1. SOIL FORMS

Three soil groupings were identified in the ML and along the pipeline route to the Swakop River: soils associated with the mountainous terrain, soils associated with the river systems (river channel and flood plain), and soils associated with the transition zone between the mountainous terrain and the river systems. Each of these groupings is described below and the soils distribution for the western and eastern sections of the ML, and along the pipeline route is presented on Figure 3-4, Figure 3-5 and Figure 3-6.

<u>Mountainous/rocky outcrop soils</u>

This group of soils is shallow (less than 400mm in depth) with fine grained sandy and silty loams. The soils are all founded on hard rock and return poor vegetation cover. The associated soil forms include: Mispah, Glenrosa, Clovelly and Fernwood.

<u>River system/alluvial soils</u>

This group of soils is deep (from 800mm to greater than 1500mm) and the soils vary in texture from fine grained silt and sand to pebble size material. The soils are stratified alluvial sediments that are founded on an impermeable calcrete base that acts as a vertical drainage barrier which in turn retains moisture in the soil. This phenomenon is recognised as an important contributor to the ecosystem functionality in the river systems because the additional moisture in the soils is utilized by both fauna and flora. The associated soil forms include: Oakleaf, Fernwood, Augrabies and Prieska.

FIGURE 3-4: SOILS IN THE WESTERN PART OF THE ML

FIGURE 3-5: SOILS IN THE EASTERN PART OF THE ML

FIGURE 3-6: SOILS ALONG PIPELINE ROUTE TO SWAKOP RIVER

Transition zone soils (include colluvial soils and shallow plain soils)

This group of soils is a variation of shallow and moderately deep (less than 800mm) colluvial derived materials that are founded on calcrete and/or hard rock. The soils are generally sandy loams and sandy clay loams that have a moderately high clay content and exhibit a degree of structure (weak crumbly to blocky). These soils are also moderately well sorted, unlike the stratified river system sediments. The associated soil forms include: Oakleaf, Clovelly, Hutton, Augrabies and Prieska.

3.4.2. SOIL PROPERTIES

Analysis was done of the physical and chemical properties of a number of soil samples. The results are discussed below.

pH

The majority of soils are alkaline in nature with an analysed pH of 8.1 to 8.7. This is considered to be within the accepted range for good nutrient mobility and related plant uptake and growth.

Salinity

The majority of the soils are non-saline. This is considered to be good for plant growth because highly saline soils cause plants to grow less effectively as they expend additional energy on water uptake and salt precipitation.

Fertility

Moderate to low levels of essential nutrients occur in the majority of soils. While calcium and sodium occur at sufficient concentrations, the zinc, magnesium, copper, phosphate, potassium and aluminium concentrations were lower than what is generally required for effective plant growth. No toxic elements were observed.

Cation exchange capacity (CEC)

Generally, the CEC (a measure of nutrient retention capacity) values are low due to the low clay content and organic matter in the majority of the soils. The lower the CEC value, the lower the potential of the soils to retain and supply nutrients which reduces the ability of the soil to support vegetation growth.

Erosion potential

The mountainous soils are classified as being highly erodible because of the low clay content and low organic matter content. These factors are enhanced by the steepness of slopes and limited vegetation cover. The soils in the valleys and on the plains are less erodible because of the flatness of the terrain, the increased vegetation cover, and in the case of the plains there is also the existence of the thin topsoil crust (less than 5mm). This crust may form with the accumulation of salts as a result of evaporation. The crust's full role in the ecosystem is not understood, but erosion prevention and moisture retention are logical deductions.

3.5. LAND CAPABILITY

Information in this section was sourced from the soil specialist study included in Appendix H (ESS 2009).

The land capability classification is based on the soil properties and related potential to support various land use activities. The land capability in the ML and along the pipeline route to the Swakop River is a mixture of grazing or wilderness/conservation.

3.6. NATURAL VEGETATION

Information in this section was sourced from the specialist vegetation study included in Appendix I (Yates 2009).

The vegetation of three areas has been described. These include the ML, the pipeline route from the ML to the Swakop River, and the transport route from Walvis Bay to the ML. For the ML and pipeline route, the vegetation has been described in terms of vegetation association and related communities. For the road route, available information was used to provide a background indication of vegetation occurrence.

As part of the vegetation description, a sensitivity rating has been assigned by the vegetation specialist to the various vegetation habitats/communities. A summary of the sensitivity ratings and definitions are as follows:

- least sensitive - partial loss of such habitats is not expected to have a significant impact on the ecosystem and habitats may be re-creatable;
- sensitive - partial loss of such habitats is not expected to have a significant impact on the ecosystem. It may be difficult to recreate these habitats and species re-establishment will be variable;
- highly sensitive - partial loss of such habitats is expected to have a significant impact on ecosystem functioning. The maintenance of patches will be critical for the long term survival of the related ecosystem and for any chances of restoration success; and
- irreplaceable - partial loss of such habitats is expected to have a significant impact on ecosystem functioning and may impact on species diversity. Some of these habitats will be impossible to recreate once physically destroyed, whilst other habitats may be re-creatable to some extent.

3.6.1. VEGETATION IN THE ML

The different vegetation associations and communities are listed and discussed below. This section should be read with reference to Figure 3-7.

FIGURE 3-7: VEGETATION COMMUNITIES IN THE ML

The *Commiphora glaucescens – Aloe namibensis* association

This association includes 4 communities. Table 3-2 to Table 3-5 describe these communities.

TABLE 3-2: VEGETATION COMMUNITY ASSOCIATED WITH QUARTZITE SLOPES

Community number 1.1: *Commiphora virgata – Zygophyllum cylindrifolium* sparse shrublands on quartzite slopes
Description: Found on quartzite slopes, outcrops and upper runoff channels. These are part of the larger Langer Heinrich Mountain, thus relatively limited within the study area and it is expected that the habitat may be limited beyond the study area as well. The most significant species found here is *Aloe namibensis* (Namib Aloe), which is endemic to the Central Namib, and regarded as vulnerable. Although this species can be found throughout this association, here it has the highest density. The community is typified by many large specimens of *Commiphora glaucescens* (blue-leaved Commiphora), *Commiphora virgata* (slender Corkwood), and occasional specimens of *Sterculia africana* (tick tree), all shrubs with swollen, fibrous stems that can store water. Other shrubs include *Boscia foetida* (Noeniebos) and *Euphorbia guerichiana* (paper-bark Euphorbia). A fair amount of nutritious grasses such as *Antephora pubescens* (wool grass), *Eragrostis nindensis* (eight-day love grass), *Stipagrostis uniplumis* (common bushman grass) and *Stipagrostis ciliata* (tall bushman grass) can be found on the slopes. Also conspicuous is the high diversity of sub-shrubs, most conspicuous are *Aptosimum lineare, Monechma cleomoides* (Namib perdebos), *Hermannia helianthemum* (rock Hermannia), *Petalidium variabile* (variable Petalidium), *Tephrosia monophylla* (single-leaved Tephrosia), *Barleria lancifolia* (blue Barleria) and *Zygophyllum cylindrifolium.* Scattered plants of *Euphorbia virosa* (candelabra Euphorbia), *Zygophyllum stapffii* (dollar bush), *Helichrysum tomentosulum* (aromatic Helichrysum), *Helichrysum roseo-niveum* (Namib Edelweiss) and *Sesamum marlothii* (Marloth's sesame) are commonly encountered. The composition and density of plants in this community at specific sites is very variable, depending largely on the steepness and aspect of the slope. **Community statistics:** 2 restricted endemics, 10 narrow endemics, 11 widespread endemics, 1 Red Data species, 4 protected species, 4 keystone species, 93 observed species, and 115 expected species. **Sensitivity:** Irreplaceable community habitat. **Management implications:** This community and habitat should be disturbed as little as possible. The relatively high incidence of the red-listed *Aloe namibensis*, as well as the high number of observed and expected species indicates that this area should, as far as possible, be conserved.

TABLE 3-3: VEGETATION COMMUNITY ASSOCIATED WITH GRANITES

Community number *1.2 Petalidium variabile – Aloe dichotoma* sparse shrublands on granites
Description: Granite boulders, flats and outcrops are found in localised areas in the eastern portion of ML140, where the overlying schist has eroded away. The granites closest to the present mine are just south of the driller's camp. This habitat does occur around the study area, especially towards the Swakop River and Tinkas Mountains. However, due to their position within the study site and its landscapes, these granites are expected to be significantly different in species composition compared to granites found elsewhere in the country. The variable Petalidium (*Petalidium variabile*) is a very constant species here, while the sporadic occurrence of *Aloe dichotoma* (quiver tree) makes this vegetation unit easy to distinguish. Plant distribution here is very patchy – no one outcrop will have the same species as the previous, and this is further strongly influenced by steepness, boulder size and boulder orientation. Generally south- and east-facing boulders have a higher diversity than west-facing boulders. Within the boulders are several niches where moisture is trapped to allow the persistence of species that would usually only occur further inland, these include *Croton gratissimus* (lavender Croton), *Dichrostachys cinerea* (sickle bush), *Grewia* species (raisin bushes) and the grasses *Cenchrus ciliaris* (blue buffalo grass) and *Eragrostis microcharis*. *Commiphora virgata* (slender Corkwood), *Commiphora glaucescens* (blue-leaved Commiphora), *Zygophyllum stapffii* (dollar bush), *Calicorema capitata* (grey desert-brush) *Barleria lancifolia* (blue Barleria),

Community number *1.2 Petalidium variabile – Aloe dichotoma* sparse shrublands on granites
Tephrosia monophylla (single-leaved Tephrosia), *Hermannia helianthemum (rock Hermannia), Eragrostis nindensis* (eight-day love grass), *Stipagrostis uniplumis* (common bushman grass) and *Asparagus pearsonii* (wild Asparagus) are relatively common. A fair number of large specimens of *Euphorbia virosa (*candelabra Euphorbia*), Aloe namibensis (*Namib Aloe), *Hoodia currorii* and *Aptosimum angustifolium (*Namib Aptosimum*)* are present. Shady crevices support the delicate *Helichrysum roseo-niveum (*Namib Edelweiss*), Jamesbrittenia hereroensis* (Namib Phlox), *Dauresia alliariifolius* and the rarely encountered *Engleria africana.* **Community statistics:** 5 restricted endemics, 16 narrow endemics, 18 widespread endemics, 2 Red Data species, 9 protected species, 7 keystone species, 138 observed species, and 164 expected species. **Sensitivity:** Irreplaceable community and habitat **Management implications:** This community and habitat should be disturbed as little as possible, it will be impossible to recreate it. The high number and diversity of niches available are responsible for the high plant diversity found here.

TABLE 3-4: VEGETATION COMMUNITY ASSOCIATED WITH QUARTZITE RAVINES

Community number *1.3 Sterculia africana – Enneapogon* sparse shrublands in quartzite ravines
Description: Short but steep and narrow ravines have been eroded into the quartzite just northwest and northeast of the current mining area. Although these areas are relatively small, the short term availability of surface water in perched rock-pools, as well as a significant amount of subsurface moisture, makes these rather unique microhabitats for both flora and fauna. The rock fig is located here, *Ficus cordata*, which will not be able to establish in any other habitat in the desert, as well as delicate herbs such as *Jamesbrittenia* species, and the *sub-shrub*s *Abutilon pycnodon (*desert Lantern flower)*, Camptoloma rotundifolium, Amphiasma divaricatum, Anticharis imbricata* (rock Anticharis)*, Barleria merxmuelleri* (spiny-cushion Barleria) and *Dyerophytum africanum* (desert statice). Further characteristic low trees are *Sterculia africana (tick tree)* and *Commiphora glaucescens* (blue-leaved Commiphora). Palatable perennial grasses found here are *Antephora pubescens* (wool grass) and *Enneapogon scoparius* (bottle-brush grass). The trailing *Cucumella aspera* is common on the steep slopes on the edge of the ravines, and occasionally large shrubs of the aromatic *Salvia garipensis* and *Helichrysum tomentosulum (*aromatic Helichrysum*)* can be found. The number of species will vary significantly during years, as annual species and the sub-shrubs may disappear during prolonged dry periods. **Community statistics:** 2 restricted endemics, 9 narrow endemics, 10 widespread endemics, 1 Red Data species, 3 protected species, 2 keystone species, 73 observed species, and 91 expected species. **Sensitivity:** Irreplaceable community and habitat **Management implications:** This habitat creates a channel for runoff from higher-lying slopes towards the lower-lying river systems. Together with this run-off seed, detritus and eroded sands are redistributed. Within the ecosystem this habitat is very important, and should, together with the lower-lying boulder washes, be treated as conservation areas. It is important that these systems are not impeded or obstructed, as they contribute to the health (and species diversity) of the larger Gawib River system.

TABLE 3-5: VEGETATION COMMUNITY ASSOCIATED WITH BOULDER WASHES

Community number *1.4 Petalidium variabile – Stipagrostis hochstetteriana* sparse shrublands in boulder washes
Description: Quartzite boulder washes are found wherever occasional, fast-flowing floodwaters discharge onto more level ground below ravines or quartz slopes. They are characterised by a relatively high cover of large round boulders and deep sands. The boulder washes are found mostly below the ravines coming off the Langer Heinrich Mountain, both within the mining area as well as off the northern and western slopes of the mountain. Similar habitats are expected to be very scarce throughout the Namib. The vegetation is characterised by a high but variable density of high shrubs such as *Calicorema capitata* (grey

Community number *1.4 Petalidium variabile – Stipagrostis hochstetteriana* sparse shrublands in boulder washes
desert-brush), *Commiphora virgata* (slender Corkwood), *Commiphora glaucescens* (blue-leaved Commiphora), *Boscia foetida* (Noeniebos) and the sub-shrubs *Monechma cleomoides* (Namib perdebos), *Ruellia diversifolia* (large desert Ruellia), *Asparagus pearsonii* (wild Asparagus), *Hermannia helianthemum* (rock Hermannia), *Petalidium variabile* (variable Petalidium), *Barleria lancifolia* (blue Barleria) and *Tephrosia monophylla* (single-leaved Tephrosia). *Stipagrostis ciliata* (tall bushman grass) and *Stipagrostis hochstetteriana* (Gemsbuck tail grass) are common perennial grasses. Common low shrubs include *Adenolobus pechuelii* (Namib neat's foot), *Calicorema capitata* (grey desert-brush), while the annual *Cleome foliosa* (yellow sticky Cleome) is rather conspicuous. These washes also host a wide variety of annual species, of which the composition and density will change every year, according to rainfall events. In these washes, the large boulders prevent perennial species from being washed away by flash-floods, whilst also trapping a large amount of debris and seed-material. It is thus not surprising that this community has very high species diversity, including many endemic species. Although this community will be very dynamic – easily changed by occasional flash-floods, very patchy plant distribution and very variable amount and density of annual plants, it remains a very important source area for seeds to be trapped, regenerated and re-distributed. The availability of seeds and the protection of the boulders may explain the high number of bird nests observed here below the boulders. **Community statistics:** 4 restricted endemics, 16 narrow endemics, 14 widespread endemics, 1 Red Data species, 3 protected species, 6 keystone species, 118 observed species, and 138 expected species. **Sensitivity:** Irreplaceable community and habitat. **Management implications:** As for the ravines, these boulder washes should be treated as conservation areas. They should be disturbed as little as possible, and not be impeded or obstructed, as they channel runoff coming down the ravines into the wider river systems below them. The high surface roughness contributes to a high number of seeds being stored in the sands here, which will be important for later re-vegetation of the mined portions of the Gawib River.

***Trianthema triquetra – Stipagrostis hirtigluma* association**

This association includes 4 communities. Table 3-6 to Table 3-9 describe these communities.

TABLE 3-6: VEGETATION COMMUNITIES ASSOCIATED WITH CONGLOMERATE FLATS AND SLOPES

Community number *2.1 Eragrostis nindensis – Trianthema triquetra* sparse grasslands on conglomerates
Description: Conglomerate flats and slopes are the remains of the old valley fill deposits. These deposits can still be found over some of the Langer Heinrich quartzite foot slopes, north of the mine. They are characterised by a dense layer of cobbles and boulders, with very little soil accumulated in between. Moisture retention is low, as is the availability of suitable niches for plant maintenance during prolonged dry periods. The relative harshness of the abiotic environment is reflected in the almost absent shrubby vegetation, represented mostly by *Salsola tuberculata* (Gannabos) and *Calicorema capitata* (grey desert-brush), whilst *Commiphora* species occur along the upper edges of runoff channels. *Stipagrostis* species form the dominant layer, but these may disappear during unfavourable seasons. An important species remaining is *Eragrostis nindensis* (eight-day love grass), a very low, but hardy perennial grass, that is also capable of trapping and stabilising soil due to its dense basal tuft. According to Nel (1983), it can complete its entire annual growth cycle with only 20 mm of rain. Although it does not have a very high production, in the Namib it is readily consumed by animals, which is partly attributable to the fact that this is often the only grass species present, and also one of the first species to resprout after rains. Further species indicative on these plains are *Trianthema triquetra*, *Enneapogon desvauxii* (eight-day grass) and *Zygophyllum simplex*. **Community statistics:** 1 restricted endemics, 7 narrow endemics, 3 widespread endemics, 1 protected species, 2 keystone species, 50 observed species, 63 expected species

Community number *2.1 Eragrostis nindensis – Trianthema triquetra* sparse grasslands on conglomerates
Sensitivity: Sensitive community and habitat **Management implications:** Disturbance to these habitats should be limited as far as possible. However, should some of these areas be physically destroyed, it is anticipated that the impact thereof on the larger ecosystem will not be highly significant. Rehabilitation may be possible to some degree.

TABLE 3-7: VEGETATION COMMUNITY ASSOCIATED WITH PEGMATITE INTRUSIONS

Community number *2.2 Adenolobus pechuelii – Zygophyllum cylindrifolium* sparse grasslands on pegmatite intrusions
Description: The pegmatites are relatively hard intrusions, with either a calcareous hardpan or a high content of quartz or feldspar, that can be found in bands spanning across the schist mountains and outcrops on the northern-eastern side of the ML, as well as on the small schist outcrops just west of the Gawib river where it turns north around the Langer Heinrich Mountain. Species diversity is relatively low, with *Adenolobus pechuelii* (Namib neat's foot) and *Zygophyllum cylindrifolium*, and occasionally *Petalidium canescens* being the most conspicuous low shrubs. These ridges are the ideal habitat for species such as *Larryleachia marlothii, Lithops* species (Beeskloutjies) and *Avonia albissima (*Pigeon-foot), all of which are protected, and have a limited distribution which is even more limited by suitable habitat availability. These species regenerate and establish slowly, and are also slow-growing. All three species rely on moisture from dew and occasional fogs that condense on the light-coloured stones and small rocks in their habitat. In the mining environment, these species will be the most likely to be suffocated by dust that seals the soil surface and prevents condensed moisture to penetrate into the soils. Other species commonly found here are *Aptosimum lineare*, *Eragrostis nindensis* (eight-day love grass), *Enneapogon desvauxii* (eight-day grass), *Euphorbia phylloclada* and *Stipagrostis ciliata* (tall bushman grass). The species composition varies significantly between the various sites, being strongly influenced by the prevailing soil characteristics and to some degree by the surrounding vegetation. **Community statistics:** 3 restricted endemics, 11 narrow endemics, 9 widespread endemics, 1 Red Data species, 3 protected species, 4 keystone species, 83 observed species, and 108 expected species. **Sensitivity:** Irreplaceable community and habitat. **Management implications:** Although species diversity is low, due to the nature of the substrate it will be impossible to re-create this habitat once it is destroyed. Dust plumes from mining operations must be prevented from settling on these pegmatites, especially on the outcrops just west of the Gawib River turn to the west of the ML.

TABLE 3-8: VEGETATION COMMUNITY ASSOCIATED WITH SCHIST RIDGES

Community number *2.3 Enneapogon desvauxii – Pegolettia senegalensis* sparse grasslands on schist ridges
Description: This community is found on the upper and usually flatter schist ridges of the northern parts of the Schieferberg as well as the schist mountains overlying the granites and covering the larger areas of the north-eastern ML. Soils are relatively shallow, and moisture retention is low. Added to that, the high cover of rock-fragments will see water from rainstorms rather running off that infiltrating. Most of the vegetation is made up of short-lived ephemerals, of which *Stipagrostis hirtigluma* often forms the dominant layer, with patches of *Stipagrostis ciliata* (tall bushman grass), and *Enneapogon desvauxii* (eight-day grass) being almost always present, albeit in low numbers. The semi-succulent herbs *Trianthema triquetra* and *Zygophyllum simplex* is a common feature on these ridges, as are *Euphorbia phylloclada* and *Pegolettia senegalensis,* and *Indigofera auricoma (*pink desert Indigofera). All these annual species can occur either solitary or in vast numbers, depending not only on total rainfall, but also rainfall pattern. Solitary plants of the stem succulents *Hoodia currorii* (Namib Hoodia) and *Euphorbia virosa* (candelabra Euphorbia) can be found, whilst occasional shrubs of *Euphorbia guerichiana* (paper-bark Euphorbia) and *Commiphora saxicola (*rock Corkwood) are also present. These localised shrubs may be the only vegetation present here during periods of prolonged drought.

Community number *2.3 Enneapogon desvauxii – Pegolettia senegalensis* sparse grasslands on schist ridges
Community statistics: 1 restricted endemics, 6 narrow endemics, 3 widespread endemics, 3 protected species, 2 keystone species, 55 observed species, and 71 expected species. **Sensitivity:** Least sensitive community and habitat. **Management implications:** Schist ridges have a fairly widespread distribution in the Central Namib. The physical destruction of limited portions of this habitat is not expected to have a significant impact on the functioning of the wider ecosystem.

TABLE 3-9: VEGETATION COMMUNITY ASSOCIATED WITH SCHIST RUNOFFS

Community number *2.4 Petalidium canescens – Commiphora saxicola* sparse grasslands in schist runoffs
Description: The presence of this community on the schist mountains and outcrops is dictated by topographical features such as steeper slopes, aspect of slope as well as runoff channels. The densest patches of this community are found in the upper edges of the runoff channels, where more water collects. The most conspicuous species here is the shrub *Commiphora saxicola (*rock Corkwood), of which numerous young individuals have been observed, as well as specimens with a considerable amount of fruit. Another common shrub is *Cryptolepis decidua*. The sub-shrubs *Anticharis imbricata (*rock Anticharis), *Petalidium canescens, Psilocaulon salicornioides* and *Tephrosia dregeana* are common, occasionally in higher densities. *Stipagrostis* species often form the dominant layer of the vegetation, but during dry seasons, only patches of *Stipagrostis uniplumis (*common bushman grass) and *Stipagrostis ciliata* (tall bushman grass) may remain. Annual species that area nearly always present after rains, but whose densities may fluctuate enormously, are Enneapogon desvauxii (eight-day grass), *Pegolettia senegalensis*, *Indigofera auricoma (*pink desert Indigofera), *Euphorbia phylloclada* and occasionally *Lotononis schreiberi*. Species composition in the runoff channels may vary significantly between sites, depending also on the size of the channel. In localised areas, e.g. just west of the processing plant, a large amount of sand has accumulated, greatly increasing the moisture retention ability of the habitat, which supports a higher species diversity and even bulbous species. The identity of these bulbous geophytes remains unknown, and specimens should be collected for identification whenever these are flowering. **Community statistics:** 8 narrow endemics, 2 widespread endemics, 2 keystone species, 52 observed species, and 69 expected species. **Sensitivity:** Sensitive community and habitat. **Management implications:** This habitat is more restricted than the schist ridges, and physical disturbance or destruction should be limited to areas that do not have large runoff-channels feeding into the lower-lying schist rivers, which are an important habitat and ecosystem links. Slopes with accumulated sands should also be treated as conservation areas, because in addition to the higher species diversity, they may form a localised unique habitat for other fauna.

***Zygophyllum stapffii – Sesamum marlothii* association**

This association includes one community as described in Table 3-10.

TABLE 3-10: VEGETATION COMMUNITY ASSOCIATED WITH NARROW SCHIST WASHES

Community number *3.1 Zygophyllum stapffii – Sesamum marlothii* riverine shrublands in narrow schist washes
Description: Relatively narrow flood channels between steeper schist outcrops and mountains, with schist gravel

Community number *3.1 Zygophyllum stapffii – Sesamum marlothii* riverine shrublands in narrow schist washes
and / or boulders, mostly south of the mine, feeding into the Gawib River from the Schieferberg. The shrubs *Calicorema capitata* (grey desert-brush) and *Zygophyllum stapffii (*dollar bush*)* form the dominant part of this vegetation, often reaching a high density and surface cover. *Stipagrostis hirtigluma* may be equally common during favourable seasons, whilst *Stipagrostis ciliata* (tall bushman grass) and *Stipagrostis uniplumis* (common bushman grass) have a more patchy distribution, but sometimes form dense stands. Common *sub-shrub*s are *Anticharis imbricata* (rock Anticharis)*, Petalidium canescens* and *Tephrosia dregeana*. Common herbs include *Indigofera auricoma (*pink desert Indigofera), *Sesuvium sesuvioides* (desert pink), *Trichodesma africanum*, *Euphorbia phylloclada, Sesamum marlothii* (Marloth's sesame with its large pink flowers) and *Zygophyllum simplex*. Species diversity is moderate, yet patchy and variable between seasons. The finer-grained soils do not offer a very favourable moisture regime, yet this community may receive a high amount of runoff from surrounding slopes. This narrow riverine environment often extends far south of the mining lease area, and forms an important resource link and channel through the larger ecosystem. Testimony to this are the frequent fresh tracks of mammals found in these channels. **Community statistics:** 1 restricted endemics, 6 narrow endemics, 4 widespread endemics, 1 protected species, 3 keystone species, 56 observed species, and 78 expected species. **Sensitivity:** Highly sensitive community and habitat **Management implications:** The channels should not impeded or obstructed, and natural flow of resources to the Gawib River itself should be restored after mine closure. The steepness of the surrounding catchments of these rivers, as well as the absence of finer deposited materials indicates that floods, should they occur, come with a high velocity and could carry materials very far – possible into the Swakop River; hence these channels are highly unsuitable for any type of material storage or dumping.

***Calicorema capitata – Stipagrostis schaeferi* association**

This association includes 3 communities. Table 3-11 to Table 3-13 describe these communities.

TABLE 3-11: VEGETATION COMMUNITY ASSOCIATED WITH SANDY RIVERS

Community number *4.1 Acacia erioloba – Stipagrostis damarensis* sparse shrublands with low trees in sandy rivers
Description: This community is found on the deep sands that have accumulated in the flood channel of the Gawib River, as well as the smaller river draining out of the eastern-most extent of the ML. The most conspicuous element of this community is large trees of *Acacia erioloba* (camel thorn), in varying density, also occasionally *Maerua schinzii* (ringwood tree), *Euclea pseudebenus* (false ebony), *Parkinsonia africana* (green hair thorn) and the waxy-leaved shrub *Salvadora persica* (mustard tree). In the upper (eastern) parts of the Gawib River, large specimens of *Euphorbia damarana* (Damara Euphorbia) can be found. The shrub-like *Stipagrostis damarensis*, as well as *Stipagrostis schaeferi* and *Stipagrostis ciliata* (tall bushman grass) are the most important perennial grasses, whilst the annual grass *Brachiaria glomerata* is also characteristic. The above perennial species are complemented by several other shrubby and many herbaceous species. The density and species composition of this community varies enormously, and will also do so from year to year, but species diversity is relatively high, with a large number of endemic species. The tree species depend on the deep soils and moisture regime only found here to be able to grow vigorously. Also, many of these large trees are most likely hundreds of years old, meaning that should all of this habitat be destroyed, it will be impossible to re-create it. These large trees, as keystone species, create important micro-habitats for an array of other plant species, accumulate litter and also create a special habitat and resource for a variety of fauna. **Community statistics:** 2 restricted endemics, 16 narrow endemics, 14 widespread endemics, 5 protected species, 7 keystone species, 127 observed species, and 148 expected species.

Community number *4.1 Acacia erioloba – Stipagrostis damarensis* sparse shrublands with low trees in sandy rivers
Sensitivity: Irreplaceable community and habitat **Management implications:** Much of this habitat overlies the ore body. Mining should be restricted to sites where ore has been physically confirmed, the remainder of this habitat should be treated as conservation area. Accessory infrastructure such as waste rock dumps and stockpiles should not be placed in this area. Topsoil conservation is important for habitat reinstatement of disturbed areas.

TABLE 3-12: VEGETATION COMMUNITY ASSOCIATED WITH RIVER TERRACES

Community number *4.2 Acacia erioloba – Stipagrostis ciliata* sparse shrublands with low trees on river terraces
Description: Sandy or gravely river terraces, mostly bordering the Gawib River. The exact delineation of this community may change continuously as a result of occasional floods. Although not flooded directly, the soils will accumulate and retain moisture from the nearby flood channels in sufficient amounts to sustain large specimens of trees and large shrubs. Soils may be more gravely between the Langer Heinrich and Schieferberg, but become sandy plains and occasionally very broad runoff channels towards the eastern part of the ML, en route to Bloedkoppie. *Calicorema capitata* (grey desert-brush), *Zygophyllum stapffii (*dollar bush*)* and *Adenolobus pechuelii* (Namib neat's foot) are relatively common shrubs, interspersed by large specimens of *Acacia erioloba* (Camel thorn). *Stipagrostis ciliata* (tall bushman grass) and *Stipagrostis hirtigluma* and occasionally *Stipagrostis obtusa* (short bushman grass) form the dominant grasses. The herb layer is very diverse, but varies significantly between sites. Very common are the annual herbs *Helichrysum candolleanum*, *Cleome foliosa* (yellow sticky Cleome), *Hermannia solaniflora*, *Indigofera auricoma (*pink desert Indigofera), *Tephrosia dregeana, Dicoma capensis,* and *Sesuvium sesuvioides* (desert pink), whilst the geophyte *Grielum sinuatum* is most abundant here, as are other bulbous geophytes, which still need to be collected for identification when in full bloom. Species diversity and density may fluctuate between years, and may lead to an underestimation of the community's importance during prolonged periods of drought. **Community statistics:** 2 restricted endemics, 9 narrow endemics, 9 widespread endemics, 4 protected species, 7 keystone species, 87 observed species, 110 expected species **Sensitivity:** Highly sensitive community and habitat. **Management implications:** As for the sandy river beds, much of this habitat overlies the ore body. Mining should be restricted to sites where ore has been physically confirmed, the remainder of this habitat should be treated as conservation area. Accessory infrastructure such as waste rock dumps and stockpiles should not be placed in this area. Topsoil conservation is important for habitat reinstatement of disturbed areas.

TABLE 3-13: VEGETATION COMMUNITY ASSOCIATED WITH SHALLOW WASHES

Community number *4.3 Adenolobus pechuelii – Stipagrostis ciliata* sparse shrublands with low trees in shallow washes
Description: Small shallow washes and drainage channels are distributed throughout the ML between foot slopes, sloping plains and flatter plains. The washes usually have a relatively conspicuous cover of *Adenolobus pechuelii* (Namib neat's foot) and *Stipagrostis ciliata* (tall bushman grass), while *Cleome foliosa* (yellow sticky Cleome) and *Heliotropium oliveranum* may be common after rains. Larger washes often have a fair number of *Calicorema capitata* (grey desert-brush) shrubs. The geophytic *Citrullus ecirrhosus* (Namib tsamma) grows abundantly in the larger washes, where it is a valuable source of food for smaller mammals, including porcupines. This plant may not resprout during very dry years, but will be very noticeable after good rains.

Community number *4.3 Adenolobus pechuelii – Stipagrostis ciliata* sparse shrublands with low trees in shallow washes
Common annual herbs include *Sesuvium sesuvioides* (desert pink), *Indigofera auricoma (*pink desert Indigofera), *Euphorbia phylloclada*, and *Tephrosia dregeana*. Total species diversity will depend to some degree on the species present around these washes, as well as the steepness of the washes and the presence of larger obstructing shrubs, both of which will influence the amount and type of seed added to the seed bank. **Community statistics:** 3 restricted endemics, 10 narrow endemics, 11 widespread endemics, 2 protected species, 4 keystone species, 96 observed species, and 115 expected species. **Sensitivity:** Highly sensitive community and habitat. **Management implications:** The bands of this habitat form small 'greener' bands due to a higher moisture retention than the surrounding plains, and may then have the only vegetation present on plains during periods of prolonged drought. Although the habitat is sensitive, localised loss of this habitat, especially smaller channels, may not significantly impact the ecosystem. It is also expected that runoff channels will re-create themselves after larger rainfall events, but species re-establishment may take much longer.

Stipagrostis obtusa – Zygophyllum simplex association

This association includes 2 communities. Table 3-14 to Table 3-15 describe these communities.

TABLE 3-14: VEGETATION ASSOCIATED WITH GRAVEL PLAINS

Community number *5.1 Aizoanthemum rehmannii – Monechma desertorum* sparse grasslands on gravel plains
Description: This habitat is most prominent on the low undulating plains off the schist outcrops in the west of the ML south of the Gawib River. Smaller patches of this community occur east of the mine as well, and extend further east into the mining area. Soils either have some finer surface calcrete or a sub-surface calcrete crust, else a high amount of finer schist gravel. Only very few and sparse perennial shrubs occur, such as *Commiphora saxicola* (rock Corkwood) and *Calicorema capitata* (grey desert-brush). The bulk of the plant species found here are short-lived ephemerals. The grasses *Stipagrostis ciliata* (tall bushman grass), *Stipagrostis obtusa* (short bushman grass) and *Stipagrostis hirtigluma* are the dominant species during favourable seasons. Annual herbs that are commonly encountered, albeit in greatly varying densities, are *Aizoanthemum rehmannii*, *Sesuvium sesuvioides* (desert pink), *Monechma desertorum*, *Lotononis schreiberi*, *Kohautia caespitosa* (desert perfume – scent is released at dusk), *Zygophyllum simplex* and *Euphorbia phylloclada*. During dry years these low footslopes and plains may remain bare. **Community statistics:** 1 restricted endemic, 6 narrow endemics, 4 widespread endemics, 1 keystone species, 59 observed species, 76 expected species. **Sensitivity:** Least sensitive community and habitat. **Management implications:** A large number of remnants of bulbous geophytes have been observed here, but species need to be collected for identification when in flower. These are unlikely to survive in the topsoil stripping and storage process so they need to be collected and replanted with their growing tips facing upwards to be able to re- establish. The partial physical destruction of the habitat may not have a significant impact on the ecosystem overall. However, it is expected that it will lead to some loss of biodiversity, especially the yet unknown bulbous species. In addition, restoration success cannot be predicted, as the layering of the topsoil and the crust seems to be the aspects determining species establishment, and there is little experience on restoring this habitat.

TABLE 3-15: VEGETATION COMMUNITY ASSOCIATED WITH QUARTZ GRAVEL PLAINS

Community number *5.2 Salsola tuberculata – Jamesbrittenia barbata* sparse grasslands on quartz gravel plains
Description: Plains with light-coloured, somewhat rounded quartz pebbles on top of a layer of very fine sand, possibly overlying a calcrete crust are the habitat of this community. These plains occur mostly west of the ML, into the EPL, north-and westwards of the schist gravel plains. Vegetation is very sparse, and usually restricted to irregularly-shaped clumps of dense vegetation, with larger areas of bare gravel in-between. These clumps of vegetation usually consist of some larger specimens of *Stipagrostis ciliata* (tall bushman grass), *Calicorema capitata* (grey desert-brush) and *Gomphocarpus filiformis.* Most of the species present here, including *Cleome paxii*, *Triraphis pumilio*, *Enneapogon desvauxii* (eight-day grass), *Aristida parvula*, *Stipagrostis subacaulis*, *Sporobolus nebulosus, Polygala pallida, Zygophyllum simplex* and *Aptosimum lineare* are below 15 cm tall. The low shrubs *Jamesbrittenia barbata* and *Salsola tuberculata* are usually also not higher than 30 cm. The vegetation patches are most likely facilitated by subsurface soil features, but the increased surface roughness created by the grasses facilitates the trapping of finer sands and debris on these small areas, which is believed to be beneficial to the vegetation. **Community statistics:** 2 restricted endemics, 7 narrow endemics, 2 widespread endemics, 1 keystone species, 40 observed species, 46 expected species. **Sensitivity:** Least sensitive community and habitat. **Management implications:** A large number of remnants of bulbous geophytes have been observed here, but species need to be collected for identification when in flower. These are unlikely to survive in the topsoil stripping and storage process so they need to be collected and replanted with their growing tips facing up to be able to re-establish. The soil seems to be uniquely layered and the study of some soil profiles may be necessary to determine how best to treat topsoil issues for restoration purposes. It appears that regeneration of these plains may be very difficult once the soil is compacted. Overall, the partial destruction of these plains is expected to cause some loss of biodiversity, but not have a significant impact on the overall ecosystem functioning.

3.6.2. VEGETATION ALONG THE PIPELINE ROUTE FROM THE ML TO THE SWAKOP RIVER

Vegetation associated with 4 sections of the pipeline is discussed below. This section should be read with reference to Figure 3-8.

FIGURE 3-8: VEGETATION SECTIONS ALONG THE SWAKOP RIVER WATER SUPPLY PIPELINE ROUTE

Pipeline section A – slopes of Langer Heinrich Mountain

The Langer Heinrich Mountain is represented primarily by the *Commiphora glaucescens – Aloe namibensis* association which comprises three vegetation types, namely *Commiphora virgata – Zygophyllum cylindrifolium* sparse shrublands on quartzite slopes, *Petalidium variabile – Aloe dichotoma* sparse shrublands on granites and *Sterculia africana – Enneapogon* sparse shrublands in quartzite ravines. Detailed descriptions of these vegetation communities are provided in Section 3.6.1. This vegetation association has been rated as irreplaceable in terms of sensitivity rating. The main ecological drivers that maintain ecosystem functioning and determine the diversity of flora of these mountainous systems include a variety of niche sites in which to establish localised improved water retention, and thus increased water availability.

Pipeline section B - Plains

The plains located between the Langer Heinrich Mountain and the Swakop River hills are dominated by two communities, namely *Salsola tuberculata – Jamesbrittenia barbata* sparse grasslands on quartz gravel plains and *Adenolobus pechuelii – Stipagrostis ciliata* sparse shrublands with low trees in shallow washes. Descriptions of these vegetation communities are provided in Section 3.6.1. The *Salsola tuberculata – Jamesbrittenia barbata* community was rated as least sensitive and the *Adenolobus pechuelii – Stipagrostis ciliate* washes as highly sensitive. The main ecological drivers that maintain ecosystem processes / functioning of these plains and washes include: periodic flash floods and localised rain events that recharge shallow aquifers in the washes, regular winds that transport nutrients, seeds and pollinators into and out of the system, biological and chemical soil crusts that stabilise the soils and prevent erosion and scattered perennial shrubs that provide habitat for fauna and act as wind traps, allowing for the accumulation of nutrient-bearing sand and seeds.

Pipeline section C – Granite boulders and boulder washes

The granite boulders and quartzite washes found adjacent to the Swakop River and on the northern slopes of Langer Heinrich Mountain are indicated to be as species rich as those washes found on the southern side of Langer Heinrich Mountain (vegetation community is *Petalidium variabile – Stipagrostis hochstetteriana* sparse shrublands in boulder washes) and the granite boulders found on the eastern side of the ML (vegetation community is *Petalidium variabile – Aloe dichotoma* sparse shrublands on granites). Descriptions of these vegetation communities are provided in Section 3.6.1. Both of these vegetation communities were assessed as irreplaceable in terms of sensitivity rating. Like the quartzites of Langer Heinrich Mountain, the main ecological drivers that maintain ecosystem functioning and determine the diversity of flora of these granite boulder systems include a variety of niche sites in which to establish localised improved water retention, and thus increased water availability.

Pipeline section D – Swakop River

The Swakop River is an ephemeral riverine system that includes the main flood channel and associated floodplains, a riparian fringe, seepage lines and river source sponge areas. A dense growth of *Sporobolus robustus* or more open communities of *Eragrostis spinosa* are found along dry riverbeds such as the Swakop River. Trees of *Acacia erioloba* (camel thorn) form dense stands with *Faidherbia albida* (ana tree), *Tamarix usneoides* (wild tamarisk), *Salvadora persica* (mustard tree), and the exotic *Nicotiana glauca* (wild tobacco) and *Presopis* sp (mesquite), native to South and Central America (White 1983). The main ecological drivers that maintain ecosystem functioning of this river include the flow regime that governs the quantity of water coming into and leaving the system, the quality of the water, the geology and soil structure of the river channel and the establishment of vegetation islands.

3.6.3. VEGETATION ALONG THE ROAD ROUTE

Vegetation associated with 4 sections of the main road route are discussed blow. This section should be read with reference to Figure 3-9.

Section A – C14 between Walvis Bay and Dune 7

The dominant soils are dune sands and the dominant vegetation structure is grassland and dwarf shrublands. Along this section of the sand sea, vegetation is very sparse and is mainly found close to the coast. The main species found are isolated hummocks of *Trianthema hereroensis* and *Psilocaulon species.*

Section B – D1198 from Dune 7 to C28

The salt road runs behind the dunes roughly following the boundary between the southern desert and central desert vegetation types. The dominant soils of the central desert vegetation type are petric gypisols and petric calcicols. Petric soils are characterized by a solid layer at shallow depth that remains hard even when wet. Gypisol soils are rich in calcium sulphates and calcicols are calcium carbonate rich (Mendelsohn, 2003). The dominant vegetation structure includes sparse shrubs and grasses. Close to Dune 7 are a number of stands of reeds. These are all artificial environments associated with the NamWater pump stations. The dominant vegetation along this section is sparse but includes clumps of dollar bushes (*Zygophyllum stapffii*), pencil bushes (*Arthraerua leubnitziae)* and *Psilocaulon species*. Crustose lichens are also associated with the gravel plains.

FIGURE 3-9: VEGETATION SECTIONS ALONG ROAD ROUTE

Section C – C28 up to the mine turn off

C28 turnoff from Salt road to Namib-Naukluft Park border and Walmund substation (0 to 19km)

The flats here are almost devoid of any shrubs, grasses and forbs. However, the gypsum and gravel flats are in places densely covered by lichens. *Arthraerua leubnitziae* occurs sparsely in small drainage lines along the road. Other species include *Zygophyllum stapffii* and *Galenia africana*.

Walmund substation to first Welwitschia mirabilis plants (19 to 29km)

The vegetation in shallow drainage lines becomes progressively denser. The dominant dwarf shrubs are the pencil bush *Arthraerua leubnitziae* and the dollar bush *Zygophyllum stapfii,* while individuals of *Gomphocarpus filiformis*, the Namib tsamma *Citrullus ecirrhosus*, the small bushman grass *Stipagrostis obtusa*, desert pink *Sesuvium sesuvioides* and the desert thistle *Blepharis grossa* occur locally.

Welwitschia mirabilis section (29 to 41km)

Small populations of the protected and well known welwitschia *(Welwitschia mirabilis)* occurs on the plains and in shallow drainage lines together with species such as *Arthraerua leubnitziae, Gomphocarpus filiformis, Sesuvium sesuvioides*, and *Galenia africana*. The southern limit of *Welwitschia mirabilis* is the Kuiseb River near Natab. Much larger populations are found north of here at the Welwitschia flats (located in the northern most section of the Namib Naukluft Park, near the Swakop river) and at the Messum crater (located west of the Brandberg).

Gravel plains and drainage lines with dolomite, quartz and limestone outcrops (41 to 52km)

In addition to the species seen on the gravel plains, new species observed in along this section include *Parkinsonia africana, Acacia reficiens* and *Commiphora saxicola*. The dominant shrubs are still *Arthraerua leubnitziae* and *Zygophyllum stapfii.* On a limestone outcrop to the south of the road *Aloe asperifolia, Salsola tuberculata* and the grass *Enneapogon desvauxii* are prominent species.

Section D – access road from C28

Stipagrostis obtusa patches (start of access road (0 to 20km)

Distinct 'fairy circles' or round patches covered by *Stipagrostis obtusa*, and occasionally with *Sesuvium sesuvioides and Psilocaulon cf. salicornioides,* occur on the flat sandy and gravelly plains. A small granitic outcrop occurs at 71km next to the road on the northern side. Characteristic species include *Monechma cleomoides, Calicorema capitata, Euclea pseudebenus, Salvadora persica, Blepharis obmitrata* and *Petalidium variabile.*

Gravel and rocky plains up to the entrance of the mine site (20 to 35 km)

This area is almost devoid of vegetation except for the drainage lines where *Parkinsonia africana*, *Acacia reficiens* and *Calicorema capitata* occur.

3.7. ANIMAL LIFE – INVERTEBRATES

Information in this section was sourced from the specialist invertebrate study included in Appendix I (Irish 2009).

Invertebrates are a key component of any ecosystem in terms of absolute numbers, biomass and ecosystem function. In determining the baseline for invertebrates, the specialist used an approach based on trophic guilds and habitats.

Sensitivity ratings for habitats were assigned in a similar manner as for vegetation (Section 3.6).

3.7.1. TROPHIC GUILDS

Trophic guilds are aggregates of species that share similar trophic resources, i.e. depend on the same food sources within a particular habitat. The following invertebrate trophic guilds were identified in the LHU area:

- Herbivores – eating live plant matter, including:
    - leaf-eaters (folivores);
    - flower feeders – includes nectarivores (nectar feeders) and palynivores (pollen feeders);
    - fruit feeders – includes frugivores (strict fruit feeders) and granivores (seed eaters);
    - sap feeders (mucivores);
    - wood eaters (xylophages);
    - grass eaters (graminivores); and
    - fungus feeders (fungivores).
- Recyclers – eating dead plant or animal remains or products, including:
    - detritus feeders (detritivores) – eating dead, dry plant remains;
    - dung feeders (coprophages) – eating vertebrate faeces; and
    - scavengers (necrophages) – eating dead animal remains.
- Predators – killing and eating other animals.
- Parasites – living in or on other animals, feeding on them without killing them outright.

The presence of a food source in a particular habitat can be used to infer the presence of the relevant trophic guild in that habitat, and vice versa. When dealing with host-specific taxa, more detail is possible, e.g. the conspicuous presence of the prey-specific predators, Pompilidae wasps, infers the presence of their less-conspicuous prey, spiders.

A full list of invertebrates observed and/or collected, with their trophic guild associations, is provided in the invertebrate specialist report (Appendix I).

3.7.2. HABITATS

Invertebrate communities in the Namib are largely determined by substrate differences. During the assessment of the ML, substrate was therefore used as an initial basis for habitat delineation. Ten habitats were identified and investigated. These are listed and discussed in Table 3-16 to Table 3-25 . This section must be read with reference to Figure 3-10.

TABLE 3-16: INVERTEBRATE HABITAT – GAWIB RIVER, TREE LINED CHANNEL

Habitat 1 - Gawib River, tree-lined channel
Description: A wide flat-bottomed wash, characterised by the presence of numbers of large trees, particularly *Acacia erioloba* (camel thorn). The substrate is sandy. Besides trees, the vegetation also consists of perennial grass. **Occurrence in ML:** Covers the western part of the main channel of the Gawib River, running from south-east to Northwest across the central part of the ML. **Occurrence elsewhere in the Central Namib:** The habitat extends only marginally outside the ML. Only two other significant occurrences of similar habitat elsewhere in the Central Namib are known: around Ganab and at Kriess se Rus. The Ganab habitat patch is situated approximately 40 km south-southeast of LHU, and is of similar extent to that in the Gawib. The habitat patch at Kriess se Rus, approximately 60 km south-southeast of LHU, is considerably larger. It must be emphasised that no studies on either have been done, and the perceived similarity is merely an informed specialist opinion. Superficially similar watercourses outside the Central Namib, e.g. the Tsondab or Tsauchab Rivers further south, or the Lower Hoanib in the north, are expected to have very different invertebrate communities due to the underlying biodiversity in these areas being fundamentally different from that in the Central Namib. **Trophic guilds**: leaf-eaters, flower, nectar and pollen feeders, fruit and seed feeders, sap feeders, wood eaters, grass eaters, limited fungus feeders, detritus feeders, dung feeders, scavengers, predators, parasites. **Sensitivity:** Highly sensitive community and habitat. **Invertebrate habitat determinants**: The mere presence of trees expands the habitat significantly into the third dimension, and increases the number of niches available. Trees also facilitate the existence of tree-dependent trophic guilds like wood eaters. Groundwater-sustained trees like these provide a dependable annually available resource to leaf, flower, nectar, pollen, fruit and seed eaters, in contrast to the undependable resource from rain-dependant larger plants in surrounding habitats. These particular trees are also important sources of detritus for detritivores. The relatively high presence of game (also a function of tree / shade presence) enables the presence of trophic guilds that are vertebrate-dependent, like dung feeders, scavengers or parasites. **Key ecological drivers**: Groundwater is the key element that drives this ecosystem. It sustains the large trees, which are the primary invertebrate habitat determinants. Groundwater flow is enabled by the existence of a sandy / gravely substrate that holds moisture in a shallow aquifer for long periods following rainfall. The actual amount of groundwater flow is ultimately dependent upon rainfall in the upstream catchment. **Vulnerabilities and threats:** Anything within this habitat that is detrimental to tree survival will be detrimental to habitat survival. The projected area to be mined includes most of this habitat within the ML. In the area already being mined, this habitat has been turned into an open pit, associated infrastructure, roads, and still growing rock dumps. No trees remain. Since this habitat is represented in only two other places in the Central Namib, both of which are covered by Exclusive Prospecting Licences already, the destruction of a third of the known occurrences is significant.

FIGURE 3-10: INVERTEBRATE HABITATS IN THE ML

TABLE 3-17: INVERTEBRATE HABITAT – GAWIB VALLEY, SANDY GRASS PLAINS

Habitat 2 - Gawib valley, sandy grass plains
Description: This habitat consists of level areas characterised by more or less sandy substrates, and the presence of perennial grass. Where it is found adjacent to the tree-lined channel of the Gawib River, it is distinguished from that habitat by the absence of trees. Where it adjoins the surrounding hills, eroded rock from here results in a sandy scree substrate, but it can still be distinguished from the hill habitats by the presence of perennial grass. Such areas are effectively narrow ecotones between the sandy grass plains and the hills, but they are not sufficiently ecologically distinct to merit treatment as a separate habitat, and on balance of characteristics they fit best with the sandy grass plains habitat. **Occurrence in ML:** This habitat occupies the wide east-west paleo-valley that makes up most of the ML, and it partially encloses the tree-lined channel habitat of the Gawib River in its western half. **Occurrence elsewhere in the Central Namib:** Sandy grass plains are widespread in the eastern parts of the Central Namib. **Trophic guilds:** limited leaf-eaters, limited flower, nectar and pollen feeders, limited fruit and seed feeders, sap feeders, grass eaters, detritus feeders, dung feeders, scavengers, predators, parasites. **Sensitivity:** Sensitive community and habitat. **Invertebrate habitat determinants:** The presence of perennial grass is the factor determining invertebrate habitat and the resources available to trophic guilds. It enables the presence of not only grass-eaters and specialist grass sap feeders, but also detritus feeders that utilise the dead old growth. By being a grazing resource for game, perennial grass additionally enables the presence of vertebrate associated trophic guilds like dung feeders, scavengers and parasites. **Key ecological drivers:** The sandy substrate determines the vegetation type that is possible under reigning climatic conditions. Sand has an excellent ability to retain water following rainfall events, and grasses are adapted to exploit that with their shallow lateral root systems and short life cycles. Ultimately rainfall therefore drives the seeding and growth of grass. The scarcity of trees indicates that, despite being part of the Gawib River catchment, groundwater plays little role in the maintenance of this habitat. **Vulnerabilities and threats**: Since the open pit and rolling mine infrastructure will eventually pass through a large part of this habitat, the biggest vulnerabilities are loss of topsoil and seed banks needed for post-mining rehabilitation.

TABLE 3-18: INVERTEBRATE HABITAT – SCHIST HILLS

Habitat 3 - Schist Hills
Description: The habitat consists of low, rounded hills, with parallel low and linear outcrops of Damara schists of the Tinkas Formation. The substrate is generally rocky. The vegetation is sparse and the only larger perennial plant is *Commiphora* sp. (kanniedood). At the time of the study, the habitat was covered with ephemeral grass. **Occurrence in ML:** This habitat forms the sides of the Gawib valley in the central south, and northeast of the ML, with isolated outcrops scattered elsewhere. **Occurrence elsewhere in the Central Namib:** Schist hills are widespread in the eastern part of the Central Namib. The ML includes only a relatively minor percentage of the total area of the schist hill ranges, like the Schieferberg, that extend into it. **Trophic guilds:** seasonal leaf-eaters, seasonal flower, nectar and pollen feeders, seasonal fruit and seed feeders, limited seasonal sap feeders, limited wood eaters, grass eaters, limited detritus feeders, limited dung feeders, limited scavengers, predators, limited parasites. **Sensitivity:** Least sensitive community and habitat. **Invertebrate habitat determinants:** Schist weathers fairly rapidly, so outcrops never become high. Larger rocks are found at the outcrop, and quickly diminish in size down slope of the outcrop. The outcrop itself is the only source of shelter and shade in the habitat. It is also the preferred growing place of the *Commiphora* (kanniedood) trees that are themselves important invertebrate concentrators / attractants. Compared to e.g. granite or quartzite, schist affords relatively little shelter. It is not a very invertebrate-friendly habitat. The permeability of the subvertical schist

Habitat 3 - Schist Hills
strata additionally ensures that the substrate retains little water following rainfall; therefore only ephemeral plants (mainly grass) can grow. **Key ecological drivers:** Rainfall is the primary driver of the system. This is evidenced by the fact that only one trophic resource, detritus, is known with certainty to be permanently available in this habitat; all other trophic resources are seasonal and rain-dependent. It follows that seed banks are an essential component as well; rain *per se*, without seeds to grow, would not have a major effect on the habitat. Wind is an important secondary driver. Since relatively little old (previous season) ephemeral grass visibly remains in the habitat, the implication is that most is exported as windblown detritus. This means that maintenance of seed banks is important to the habitat. **Vulnerabilities and threats:** The biggest threat to this habitat is habitat destruction. Since the substrate defines the habitat, and is also the prime invertebrate habitat determinant, the habitat is vulnerable to substrate disruption. Waste rock dumps are currently being deposited mainly on schist hills. Once anything has been dumped on a schist hill, it does not automatically become an ecologically functioning schist hill again if the dumped material is removed.

TABLE 3-19: INVERTEBRATE HABITAT – QUARTZITE HILLS

Habitat 4 - Quartzite Hills
Description: The habitat consists of very rugged hill slopes, interspersed with deep valleys. The substrate is very rocky, and rocks belong to the Etusis Formation. The vegetation is composed of a relatively large variety of single widely spaced small trees or shrubs. At the time of study there was also a covering of ephemeral grass in suitable places between the rocks. **Occurrence in ML:** This habitat comprises the foothills of Langer Heinrich Mountain, in the central north of the ML. The portion inside the ML is a relatively small part of a larger habitat block that is centered on Langer Heinrich Mountain. The geological map shows another small quartzite outcrop in the southeast of the ML. The latter is linear and narrow, surrounded by other rock types, and was considered too small to function in the same way as the main quartzite hills habitat. It was not considered further. **Occurrence elsewhere in the Central Namib:** The Etusis Formation is widespread in Central Western Namibia, but most outcrops are further inland, and they are expected to be ecologically incomparable to those at LHU, because of their different background climates. The Langer Heinrich outcrop is relatively isolated from other quartzites, and this might have resulted in the evolution of endemic taxa on the mountain, though studies to identify such possible invertebrates have not been done. A relatively large surface area under broadly similar environmental conditions to those at LHU exists in the Chuos Mountains. This is about 50 km north of LHU outside the Namib-Naukluft Park on commercial farmland, and in the vicinity of the proposed Valencia uranium mine. Given the uncertainty with regard to comparability of other outcrops, the Langer Heinrich quartzite habitat may well be more unique than its current ranking suggests. **Trophic guilds:** leaf-eaters, flower, nectar and pollen feeders, fruit and seed feeders, limited sap feeders, limited wood eaters, seasonal grass eaters, detritus feeders, limited dung feeders, limited scavengers, predators, limited parasites. **Sensitivity:** Highly sensitive community and habitat. **Invertebrate habitat determinants:** Quartzite is harder and weathers relatively slower than schist. This results in an abundance of broken bare rock slabs. In the spaces between these slabs, there is lots of shelter for invertebrates. There is also good soil, possibly because of a combination of the fact that detritus gets trapped and can contribute to soil formation, and that microclimates are milder and allow for soil formation. Milder microclimates are a result of the steepness of the terrain, which causes one or the other aspect to be in shade for longer or shorter times of the day. Better soil, plus milder microclimates, results in greater plant diversity that in turn enables the occurrence of a greater diversity of invertebrate trophic guilds. Even though the overall habitat is therefore much more invertebrate-friendly than schist hills, quartzite is also permeable to water, and the hill slopes are still relatively drier than they might have been with less permeable rock. This is evidenced by the fact that the grass on quartzite hills is also ephemeral, not perennial. Watercourses tend to form deep ravines that contribute to habitat steepness and aspect variety. Ravines are biodiversity concentrators in this habitat. **Key ecological drivers:** Rainfall is the primary driver for this system. It allows the sprouting of ephemeral grass on the one hand, but also plays a part in the weathering processes from which most habitat determinants can be derived. Wind may play a secondary role. Most ephemeral grass probably stays in the system as detritus, because they tend to get trapped between the rocks. This implies that external detritus blown into the habitat will probably

Habitat 4 - Quartzite Hills
stay there as well. Maintenance of these seed banks will be important for the habitat. **Vulnerabilities and threats:** The biggest threat is habitat destruction. It was shown above that the determinants for this habitat are complex and interconnected, but are all routed in the physical complexity of the substrate. This complex substrate is the result of processes spanning geological time-scales, and is not something that can be rebuilt after it has been destroyed or dumped on. This habitat within the ML is not the focus of mining, but it is close to the projected expansion of the open pit, and collateral habitat destruction is a threat.

TABLE 3-20: INVERTEBRATE HABITAT – GRANITE HILLS

Habitat 5 - Granite Hills
Description: The habitat consists of low outcrops of the Bloedkoppie Granite Formation, characterised by large rounded boulders and expanses of bare rock. Where there is soil, the substrate is coarse gravel. Vegetation is sparse but quite diverse, with small *Commiphora* (kanniedood) trees, shrubs and perennial grass. **Occurrence in ML:** This habitat occurs in the eastern third of the ML only, but there it is widespread in many larger and smaller outcrops. Only larger outcrops (those large enough to function as stand-alone habitats) were mapped. **Occurrence elsewhere in the Central Namib:** There is much granite in the Central Namib, and the outcrops in ML 140 are the western end of an area of scattered outcrops that extend eastwards to beyond the borders of the Namib-Naukluft Park. However, not all of this granite represents comparable habitat. In a recent study of the distributions of endemic Central Namib invertebrates, it was found that most endemic species have very narrow east-west distribution ranges. This is probably related to the steep east-west environmental gradient across the Namib. It follows that superficially similar habitats also have to be in a narrowly similar longitudinal position (i.e., at a similar distance from the coast) before their invertebrate faunas can be assumed to be possibly comparable. In the present case, the granites east of the ML do not qualify. However, geological maps do show relatively large extents of granite outcrops at the same longitude as the eastern ML, north of the Swakop River, approximately 20 km north of LHU. During the pipeline route inspection, what was seen was of comparable character to the ML. **Trophic guilds:** leaf-eaters, flower, nectar and pollen feeders, fruit and seed feeders, sap feeders, limited wood eaters, limited grass eaters, detritus feeders, dung feeders, limited scavengers, predators, parasites. **Sensitivity:** Highly sensitive community and habitat. **Invertebrate habitat determinants:** On a large scale, granite weathers into big boulders. The resultant jumbles of rock include many cavities and overhangs that afford an abundance of shade and shelter. The microhabitats within these are refuge for many species. On a smaller scale, granite weathers into flakes, and dorso-ventrally flattened invertebrates like *Thermobia* spp. are specialised to live in the cracks thus created. Run-off from the large expanses of bare rock cause a 'gutter effect', in that even small precipitation events result in a significant water input to plant communities at the edges of sheet rock. This sustains an unexpected variety of plants, and all in turn provides food or habitat for invertebrates. Since the same habitat structure also favours vertebrates, resources for dung-feeding or parasitic invertebrates become available. The complexity of the habitat ensures that most detritus produced by plants in the habitat, stays in the habitat, and detritus feeders can find abundant resources under vegetation in rock cracks. **Key ecological drivers:** Rainfall is the primary driver for the system. Through the rainfall concentration effect of bare rock, it sustains a wider variety of perennial vegetation than would have been possible for the same amount of rainfall without the rock effect. Detritus produced in the habitat stays there, and no signs were seen of significant detritus input from outside. Maintenance of seed banks is important for the habitat. **Vulnerabilities and threats**: Habitat destruction is the biggest vulnerability of this habitat. The physical complexity of the habitat on granite hills determines that it cannot be rebuilt after it has been destroyed or dumped on. The granite hills habitat within the ML is not the focus of mining, but it flanks the projected expansion of the open pit in the east. There is a threat that the habitat may be collaterally destroyed by pit-associated developments.

TABLE 3-21: INVERTEBRATE HABITAT – CONGLOMERATE HILLS

Habitat 6- Conglomerate Hills
Description: The habitat consists of low flat-topped hills with rounded profiles. The hilltops are capped by a hard flat layer of the Langer Heinrich Conglomerate Formation, and the hillsides typically weather into wide, open rock

Habitat 6- Conglomerate Hills
overhangs under this cap. The substrate is calcareous hardpan throughout. There is little perennial vegetation, and the habitat was covered with ephemeral grass at the time of study. **Occurrence in ML:** This habitat is represented by a few relatively small outcrops along the northern valley side in the central part of the ML only. **Occurrence elsewhere in the Central Namib:** Significant outcrops of the Langer Heinrich Conglomerate Formation are confined to the ML. However, these conglomerates are ecologically, if not stratigraphically, comparable to the Karpfenkliff Conglomerate Formation. The latter is widespread in the Central Namib: it is found at the type locality of Carp Cliff, elsewhere in the Lower Kuiseb River catchment, along the Lower Swakop River, and further south as far as Sesriem **Trophic guilds:** seasonal grass eaters, limited dung feeders, limited scavengers, limited predators, limited parasites. **Sensitivity:** Least sensitive community and habitat. **Invertebrate habitat determinants:** The rocks are embedded in a hard matrix. The surface of the ground is smooth and offers no shelter. The matrix weathers into a fine-grained calcareous dust, leaving rounded rocks. Smooth round rocks afford very little shelter to invertebrates, compared to the flatter, irregularly shaped rocks in other habitats. The net effect is a habitat that affords very little physical shelter. The rock overhangs are shady, but the desiccating effect of the calcareous dust results in little invertebrate utilisation of the habitat. The general hardpan everywhere in the habitat inhibits vegetation growth, limiting plant-based invertebrate guilds. In general, the conglomerate hills habitat is very invertebrate-unfriendly. **Key ecological drivers:** This is a rather inert habitat. Rainfall is a driver, but the substrate is not conducive to plant growth and it leads mainly to the sprouting of ephemeral grass. In the absence of significant detritus traps in the habitat, most ephemeral grass is exported from the system as windblown detritus. **Vulnerabilities and threats:** Habitat destruction is the biggest vulnerability. The substrate defines the habitat, and the substrate cannot be rebuilt after it has been destroyed. The conglomerate hills are not the focus of mining, but are adjacent to the current tailings facility, and will be adjacent to the extended open pit in future. The habitat may therefore be under threat of collateral destruction by pit-associated developments.

TABLE 3-22: INVERTEBRATE HABITAT – WESTERN GRAVEL PLAINS

Habitat 7 - Western gravel plains
Description: The habitat consists of wide-open, relatively flat plains. The substrate is mostly hard consolidated gravel. There is no significant perennial vegetation, but the habitat was covered in ephemeral grass at the time of the study. **Occurrence in ML:** The habitat covers almost all of the western quarter of the ML, on the open plains west of the Gawib Valley. **Occurrence elsewhere in the Central Namib:** Widespread in the Central Namib. **Trophic guilds:** seasonal grass eaters, limited dung feeders, limited scavengers, limited seasonal predators. **Sensitivity:** Sensitive community and habitat. **Invertebrate habitat determinants:** The details of the formation of consolidated desert pavement are not fully known, but at least three mutually interacting processes are involved. Firstly, there are wind erosional effects. Fine material is blown away over geological time periods, causing smaller pebbles to become concentrated in the surface layer of the ground. Secondly, there are physical crust formation effects, like fog or rainfall that bind the surface of the soil into a thin crust. This can happen within days of the triggering event. Thirdly, there are biological soil crusts. Their growth rate is unknown, but expected to be quite slow. Under natural conditions, the desert pavement is continually being renewed. Every time a zebra puts its hoof down, a piece of surface crust is crushed. The fines will blow away, leaving soil of a suitable consistency to enable the formation of a physical crust before too long, and a biological crust may eventually grow. The net effect of crust forming processes is that the soil surface is quite hard; digging is not an option for invertebrates. Pebbles are firmly stuck to the ground and the potential shelter under them is inaccessible. In the absence of shade and shelter, the habitat is thermally harsh. Many invertebrates that occur here spend the bulk of their lives in inactive stages (e.g. eggs), and only hatch after rain, when sprouting ephemeral

Habitat 7 - Western gravel plains
grass affords food, some shade, and the opportunity to escape the soil surface heat by climbing up. **Key ecological drivers:** Crust formation processes maintain the habitat. Without crusts, it would become something else, probably a dust bowl. Rainfall is the primary driver of the system. Rainfall triggers the germination of ephemeral grass, and that allows invertebrates populations to hatch. Invertebrate activity at this time can also enable the presence of insect-eating vertebrates, e.g., activity by harvester termites (*Hodotermes mossambicus*) will allow bat-eared foxes (*Otocyon megalotis*) to be temporarily active in the area. The system is a detritus exporter, so maintenance of seed banks is important to ensure new growth. **Vulnerabilities and threats**: The main threat to this habitat is habitat destruction, or more precisely, substrate disruption that curtails normal crust formation processes to the extent that the natural self-healing processes of the substrate are rendered ineffective. Unless crusts and crust formation processes stay intact, the habitat degrades quickly, and becomes uninhabitable by invertebrates.

TABLE 3-23: INVERTEBRATE HABITAT – EASTERN GRAVEL PLAINS

Habitat 8 - Eastern gravel plains
Description: The substrate consists of relatively flat ground, between and among low hills. The substrate is coarse granitic gravel. There is little perennial vegetation except along watercourses, but it was covered with ephemeral grass at the time of the study. **Occurrence in ML:** The habitat is found in the eastern quarter of the ML only. Where it is found adjacent to the superficially similar sandy grass plains of the Gawib Valley, it may be distinguished on the ground by the gravely substrate in this habitat compared to the sandy substrate in the Gawib Valley. **Occurrence elsewhere in the Central Namib:** Plains with coarse granitic gravel substrates are found associated with areas of granite outcropping throughout the Central Namib. **Trophic guilds:** limited seasonal leaf eaters, limited seasonal flower, nectar and pollen feeders, limited seasonal fruit and seed feeders, limited seasonal sap feeders, seasonal grass eaters, limited detritus feeders, limited dung feeders, limited scavengers, predators, parasites. **Sensitivity:** Sensitive community and habitat. **Invertebrate habitat determinants:** Because it is gravely, it is very permeable to water. As a result, only ephemeral grass can grow after rainfall, in contrast to the adjacent sandy grass plains where the better water retention qualities of sand allow perennial grass to grow. Because the habitat provides little other shelter, many invertebrates burrow in order to escape heat or detection; the loose gravely substrate allows this. Also noticeable in this habitat are the substrate mimics, like the stone grasshoppers (C*rypsicerus cubicus*), that escape detection by having superior camouflage and staying immobile. The fact that they were found here but not on the superficially similar western plains, indicates the different thermal properties of the two respective substrates, as well as the climatic difference caused by the short approximately 15 km longitudinal shift between them. Immobility at ground level is not a viable strategy in a habitat with lethal near-surface temperatures, like the western plains, but it does work in the east. Small (< 1 m wide) watercourses are common in this habitat. They probably exist to channel run-off from adjacent granite hillocks. Perennial shrubs grow along them and enhance the resource for herbivores guilds in this habitat. **Key ecological drivers:** Rainfall is the primary driver of the system. It allows the ephemeral grass to sprout, which enables relevant invertebrate guilds to hatch and exploit the resource. Rain also sustains the perennial shrubs along the small watercourses, which add another dimension to available food resources in the habitat. Wind does not seem to be a great driver, since the habitat is almost detritus-normal: some detritus is retained in the system, but the rest is blown away. The maintenance of seed banks is important for this habitat. **Vulnerabilities and threats:** The primary threat is habitat destruction. The projected extension of the open pit will eventually reach this habitat, or at least come close to it. The threat, if not outright destruction, remains collateral damage through pit-associated infrastructure. The area has a good rehabilitation potential, providing topsoil and seed banks are preserved.

TABLE 3-24: INVERTEBRATE HABITAT – ISOLATED WINDBLOWN SAND PATCH

Habitat 9 – Isolated windblown sand patch
Description: This is a small patch of sloping windblown sand in the lee of a schist hill. The substrate consists of deep fine aeolian sand, grading to coarser gravel along the edges. Vegetation consists mainly of perennial grasses.

Habitat 9 – Isolated windblown sand patch
Occurrence in ML: This habitat has a single occurrence in the ML only, occupying approximately 0.2 ha, right next to the main processing plant. Other patches marked as such were visited or observed from a distance, but all were found to consist of rocky substrates. **Occurrence elsewhere in the Central Namib:** Tiny windblown sand patches are found throughout the Central Namib. Each should be considered to be unique and potentially harbour endemic invertebrates until proven otherwise. A thorough search for smaller patches, like this one, has never been made. However, inspection of satellite images for an area with a radius of about 100 km around LHU indicated that there are no small patches in at least this area. It follows that the habitat is highly isolated. **Trophic guilds:** Limited Leaf-eaters. Limited Flower, Limited Fruit and seed feeders. Limited Sap feeders. Seasonal Grass eaters. Insignificant Fungus feeders. Seasonal Detritus feeders. Limited Predators. Limited Parasites. **Sensitivity:** Irreplaceable community and habitat. **Invertebrate habitat determinants:** The sandy substrate defines the habitat. Sand movement due to wind action over geological time scales has played a major part in the evolution of that system. Instances are known of endemic species being found exclusively on sand patches as small as 0.6 ha. It is not known whether any species are endemic to this particular patch yet, but individuals of two dune specialist beetle genera (*Pachynotelus* and *Leptostethus*) were recorded. Both are exclusively sand-living, specialist grass-feeders that only emerge as adults for brief periods following significant rainfall, and both belong to highly diverse genera with many endemic species that are range-restricted to particular bodies of sand. Besides aspects relating to its origin, aeolian sand also has physical characteristics that determine its suitability as invertebrate habitat. Sand's water retention qualities allow the survival of perennial grass, similar to the case for the sandy grass plains of the Gawib Valley. Though the resource is permanently available, both sand specialist grass-feeding beetles mentioned above are only active for short periods following rain. Like their ancestors, they are adapted to life on dunes where grass is not permanently available, and they continue to follow a lifestyle that is more appropriate for those conditions. Aeolian sand is also finer than riverbed or grassy plain sand, and is better suited to invertebrates burrowing for shelter. This particular sand patch also serves as an important nesting site for sand-burrowing Sphecidae wasps. **Key ecological drivers:** Whatever winds deposited this sand and its inhabitants here at whatever time in the geological past, they are no longer active. The present wind regime does not affect the sandy patch. The primary ecological driver is rainfall. Rainfall not only sustains the perennial grass, but also allows the known sand-specialist beetles to hatch and complete another life cycle. There are probably other invertebrates on this patch, besides the two encountered during this brief survey, that also respond to rain. **Vulnerabilities and threats:** The tiny size of the sand patch, its highly isolated location, the impossibility of reproducing the unique historical processes that created it and its position immediately adjacent to mining infrastructure in the process of being expanded, render it highly vulnerable. The immediate threat is complete habitat destruction by building of infrastructure on top of it. A rock dump is already covering one edge. Even if it is not destroyed, habitat disruption, e.g. by trampling, is a threat given the proximity of workplaces and the volume of human traffic around the area. Solid and liquid pollution is also a concern.

TABLE 3-25: INVERTEBRATE HABITAT – EPHEMERAL AQUATIC SYSTEMS

Habitat 10 - Cross cutting habitat – Ephemeral aquatic systems
Description: These are short-lived ecosystems associated with open water following rainfall events. Their exact nature will depend on both the amount of rainfall and the habitat in which it occurs. Their occasional presence is certain, but cannot be predicted in advance. **Occurrence in ML:** This habitat is a crosscutting one that can occur in any of the others, at unpredictable places depending on rainfall. Its potential for occurrence varies according to habitat. **Occurrence elsewhere in the Central Namib:** Will occur wherever and whenever sufficient rain falls, and the underlying substrate supports the existence of open surface water. **Trophic guilds:** limited aquatic herbivores, seasonal detritus feeders, scavengers, predators. **Invertebrate habitat determinants:** The presence of open water is the absolute determinant for this habitat, and

Habitat 10 - Cross cutting habitat – Ephemeral aquatic systems
that is determined by rainfall. The effectiveness of rainfall in creating aquatic habitats will depend on the suitability of the background habitat, as discussed above. The duration of water presence is also important – any open water that persist for less than about 4-5 days will not develop anything resembling an aquatic ecosystem. The longer the water persists (perhaps through replenishment by repeat rainfall events) the more diverse the system will become. Eventually though, it will dry up and the invertebrates will either die, fly off to find other pools, or enter into inactive stages to await the next rainfall event. So, a flash flood that passes and merely leaves the riverbed wet is not an aquatic habitat, but any pools remaining in the riverbed may or may not become short-lived aquatic habitats before they dry up again. It should be noted that more persistent water sources are being created in the LHU area by mining activities. The tailings facility is an expanse of open water, as is the reservoir at the endpoint of the Swakop pipeline, while the future heap leach pads may also belong here. These are unlikely to develop into functional aquatic habitats because of unsuitable water quality (tailings, heap leach) or constant disturbance (reservoir). **Key ecological drivers:** Rainfall is the primary driver for this habitat. **Vulnerabilities and threats:** Aquatic habitats are incongruous in a desert environment, but they do occur and need to be considered. However, they do not lend themselves to discussion at the same level as more persistent habitats. Pollution is a potential threat.

3.8. ANIMAL LIFE - VERTEBRATES

Information in this section was sourced from the specialist vertebrate study included in Appendix I (Henschel 2009).

Several vertebrate species have their eastern, western, northern or southern distribution boundaries in the vicinity of the ML, therefore explaining the high diversity of identified vertebrates. Some of these vertebrates are permanent residents while others are regular commuters or occasional transients.

Vertebrates have been identified and described by the specialist according to groups, species and habitats. A full list and discussion on groups and species is provided in the specialists report (Appendix I). In broad terms, the groups of vertebrates include: mammals, reptiles (including inter alia: snakes, skinks, lizards, geckos, and others), frogs and birds. At least 44 species of mammals, 45 species of reptiles, 2 species of frogs and over 200 species of birds occur in and around ML. Of these, 4 species of reptiles are of special conservation significance because they are newly discovered, have limited ranges, and/or very little is currently known about them: the Schieferberg sand lizard, the Damara tiger snake, the Delalande's blind snake, and the Husab sand lizard.

As with Sections 3.6 and 3.7 on vegetation and invertebrates, the focus of this Section is to describe the identified habitats that are relevant to vertebrates. Approximately 19 core habitats were identified and investigated. These are listed and discussed (sometimes similar types of habitats have been grouped together) in Table 3-26 to Table 3-44 . This section must be read with reference to Figure 3-11.

Sensitivity ratings for habitats were assigned in a similar manner as for vegetation (Section 3.6).

FIGURE 3-11: VERTEBRATE HABITATS IN THE ML

TABLE 3-26: VERTEBRATE HABITAT – GAWIB VALLEY FLOOR

Habitat 1 - Gawib valley floor
Description: This area is generally quite flat, slightly sloping towards the adjacent mountains. It is usually not as hard as the gravel plains, and the sandy gravel is not as structured as the desert pavement of the gravel plains. The valley floor comprises stones and coarse sand interspersed with dwarf shrubs and associated sand mounds (hummocks). Tributaries of the Gawib cut into the valley as sandier bands of denser vegetation. **Occurrence in ML:** It stretches along the length of the ML from the gravel plain in the west to the granite koppie in the east. **Vertebrate groups**: This habitat has high diversity: at least 18 mammals, 19 reptiles, and many bird species. There is one snake species of possible special conservation significance. Species composition regularly changes over time due to connectivity with other habitats. All trophic levels are well represented. **Sensitivity:** Sensitive community and habitat. **Vertebrate habitat determinants**: The Gawib valley is the most important connection between most of the habitats in the ML. It has heterogeneity of substrates and microhabitats ranging from sand flats and hummocks, to stony ground, from bare areas with only ephemeral grass, to patches of dwarf shrubs. It provides both refuge and food for small vertebrates. **Threats and restoration:** Much of the Gawib valley floor could be damaged. Initial rehabilitation will be relatively straight forward, given that the current soil is not well developed and the ground relatively flat. Heterogeneity is more difficult to restore, and should include re-establishment of dwarf shrubs and sandy patches on generally stony ground. This is a generalist habitat and reintroduction of species for repopulation should be possible. Connectivity should be re-established as much as possible as soon as mining is finished in an area to allow animals to move between habitats and areas (this should be kept up as much as possible, to avoid animals losing the traditional knowledge of the area).

TABLE 3-27: VERTEBRATE HABITAT – GAWIB CHANNEL ACACIA FOREST

Habitat 2 - Gawib channel acacia forest
Description: This channel is occasionally flooded following local rains in the eastern half of the Schieferberg and on the plains south of it. It has the highest density of woody plants in the study area, particularly large Acacia trees, dense Salvadora hedges, and dwarf shrubs often with large sand mounds. The substratum is either coarse, unconsolidated sand, in places stabilised by thin layers of silt/clay, or sand piled into hummocks. **Occurrence in ML:** The tree-lined channel starts south of the Schieferberg and at Bloedkoppie, which join in the eastern Gawib valley, and the line of trees runs the length of the Gawib valley, eventually continuing into the Swakop River. **Vertebrate groups**: This habitat has the highest number of species of mammals (23), reptiles (21) and birds. It is likely that not all species were recorded. **Sensitivity:** Highly sensitive community and habitat. **Vertebrate habitat determinants**: The occasional floods water the trees and transport seeds and sediments. Productivity is the highest of all habitats, and besides woody vegetation there is also a lot of perennial grass. The Acacia trees and other perennial vegetation, mounds of litter and sand, and banks of clay represent considerable resources in terms of food and good shelter to many kinds and sizes of vertebrates. There is linear connectivity for movements along the Gawib. **Threats and restoration:** Channel blockage and changes in the surface hydrology will change vegetation and substrate dynamics. Destruction of perennial vegetation, especially large and complex Acacia trees represent critical habitat loss. Loss of ground water drained by mining causing trees to die. Disruption of connectivity limits mobility and range expansion and contraction of animals. It takes centuries to re-establish a riparian forest of this nature and removal of trees and their groundwater must be avoided as much as possible. Animals will return to this resource rich habitat when the disturbance is gone and blockages of the river have been removed.

TABLE 3-28: VERTEBRATE HABITAT – UPPER GAWIB RIVER

Habitat 3 - Upper Gawib River
Description: The upper Gawib comprises a number of shallow watercourses that join near the granite koppies. From there a single broad, shallow water course continues until it joins the tree-lined middle Gawib channel. The ground is coarse sand with only few scattered stones, which in its upper reaches distinguishes it from the adjacent hard stony plain. **Occurrence in ML:** Starts at the Gawibberg east of Bloedkoppie and continues towards the middle of the ML at the end of the south-west reaches of Tinkas Mountain. **Vertebrate groups:** This habitat has a high numbers of species of mammals (22) and moderate numbers of reptiles (13). The highest densities of small mammals of all habitats occur around vegetation hummocks while the rich boundary zone with granite koppies enhances biodiversity of both habitats. **Sensitivity:** Sensitive community and habitat. **Vertebrate habitat determinants:** Perennial grasses and shrubs and a sparse scattering of Acacia trees of the upper Gawib provide food and shelter even in dry years. Large hummocks of sand have accumulated around shrubs, which mammals and reptiles dig into. Boundary areas to granite koppies are particularly productive. **Threats and restoration:** Threats include: disturbance and pollution by mining, removal of hummocks, disturbance of boundary zones and the loss of connectivity upstream-downstream for small vertebrates. Sandy substrate is straightforward to rehabilitate. It takes decades to re-grow hummock-forming dwarf shrubs and their destruction should be avoided wherever possible. Boundary zones to granite koppies can be cleared and will resume hydrological and ecological functioning.

TABLE 3-29: VERTEBRATE HABITAT – LOWER GAWIB RIVER

Habitat 4 - Lower Gawib River
Description: Its bed forms an unbroken connection of coarse sandy substrate, shrubs and trees from LHU to the Swakop River. **Occurrence in ML:** This is the continuation of the Gawib channel from the south west corner of Langer Heinrich Mountain downstream in a north-westerly direction out of the ML. **Vertebrate groups:** This habitat is comprised of many mammal species (19), moderate numbers of reptiles (12), and numerous bird species. The expansion and contraction of populations from the Swakop River changes biodiversity over time. **Sensitivity:** Highly sensitive community and habitat. **Vertebrate habitat determinants:** Vertebrates that would be more typical of the Swakop riverbed can use this relatively sheltered corridor to get from the Swakop River to LHU. **Threats and restoration:** Channel blockage and changes in surface hydrology will change the vegetation and substrate dynamics. Upstream threats in Gawib Channel Acaia will impact the Lower Gawib river. This habitat will restore naturally when the upstream Gawib channel Acacia is restored.

TABLE 3-30: VERTEBRATE HABITAT – GAWIB TRIBUTARIES FROM LANGER HEINRICH MOUNTAINS

Habitat 5 – Gawib Tributaries coming from Langer Heinrich mountains
Description: The Gawib Tributaries coming from the Langer Heinrich Mountains are characterized by steep, broken and relatively shallow rock-lined drainage lines across the foot of the ML, sandy channels with rocky banks and side channels contain sheltered water holes. A very broad, open drainage with gradually sloping stony banks that continue into the Tinkas hills. **Occurrence in ML:** The five prominent washes that drain the ML stretch into the Gawib Channel Acacia along the boundaries of the foothills quartzite bank and conglomerate. **Vertebrate groups:** This habitat has a high numbers of species of mammals (22) and reptiles (21), birds particularly attracted to water. The washes are important sources of biodiversity for the ML, for both resident animals as well as migrants.

Habitat 5 – Gawib Tributaries coming from Langer Heinrich mountains
Sensitivity: Irreplaceable community and habitat. **Vertebrate habitat determinants:** The availability of shade along the relatively more productive canyon floor, water pools and broken rock banks represent considerable resources in terms of food and good shelter to many kinds and sizes of vertebrates. **Threats and restoration:** Blockage of the mouth areas of washes blocks the mountain-valley and will impact on local and long-distance connectivity for animals. Proximity and ease of access by people could result in poaching and vandalism. Opening blocked mouths of the washes will restore the main functions and connectivity. The game corridor can resume once it is opened and zebras have learnt about this again.

TABLE 3-31: VERTEBRATE HABITAT – GAWIB TRIBUTARIES COMING FROM SCHIEFERBERG

Habitat 6 – Gawib Tributaries coming from Schieferberg
Description: The Gawib Tributaries coming from the Schieferberg are characterized by confined steep banks in the mountain, and sandy channels that widens as the wash enters and crosses the Gawib valley. The washes can vary from narrower and barely vegetated too short, narrow, and rocky. **Occurrence in ML:** The five prominent washes drain the Schieferberg, entering the Gawib valley floor. **Vertebrate groups:** This habitat has a high biodiversity of mammals (21) and reptiles (22). There are three reptile species of special conservation significance. Species from adjacent habitats namely the Gawib valley floor and Schieferberg slope, form part of a corridor for zebra (currently disturbed). **Sensitivity:** Irreplaceable community and habitat. **Vertebrate habitat determinants**: The Gawib Tributary from the Schieferberg used to be an important game corridor from Schieferberg into the Gawib valley. Availability of food, shade and other shelter along the relatively more productive canyon floor, with numerous shrubs and hummocks. Broken rock banks shelter animals that forage in the open channel. **Threats and restoration:** Blockage of the five predominant washes will prevent local and long-distance connectivity. Blockage of channels will cause changes in surface hydrology and will change vegetation and substrate dynamics. If tailings are placed across the Schieferberg, the washes and its biodiversity will be permanently destroyed, and several reptile species of special conservation significance will suffer population reductions. Destruction of perennial vegetation, especially large and complex Acacia trees represents critical habitat loss. Proximity and ease of access by people could result in poaching and vandalism. Opening blocked mouth of the washes will restore the main functions and connectivity, but may require reintroduction of some species. It will take centuries to replace the large Acacia trees. It may be necessary to undertake studies of the vulnerable species to determine the significance of population losses and plan possible compensation. Restoring productivity will take decades.

TABLE 3-32: VERTEBRATE HABITAT – PLAIN AT TINKAS ROCK SCULPTURES

Habitat 7 - Plain at Tinkas Rock sculptures
Description: It is a hard-surfaced gravel plain that gently slopes eastwards towards the Tinkas River (which is located beyond the ML). This plain is confined by schist, granite and quartzite hills, and abuts the sandy plain of the Upper Gawib. The Tinkas Rocksculptures Plain is laced with shallow watercourses between which the gravel is stable and the surface is firm. **Occurrence in ML:** Across the eastern 2-km of the ML. The Tinkas Rocksculptures Plain is named after the tourist walking trail through the granite koppies along the southern border of the plain. **Vertebrate groups:** This habitat has a low abundance of animals, mammals (19) and reptiles (8). Residents tend to be plains specialists. Species from different adjacent habitats also use plains. **Sensitivity:** Least sensitive community and habitat. **Vertebrate habitat determinants:** The Tinkas Rocksculptures Plain has a high degree of exposure and low productivity. Substrate is stable and well suited for establishing burrows. This habitat allows for runoff and species exchange with different adjacent habitats.

Habitat 7 - Plain at Tinkas Rock sculptures
Threats and restoration: Off-road driving destroys many small burrows. Mining activities may permanently destroy stable surfaces and disturb rich communities in adjacent habitats. Restoration of this habitat could establish a habitat similar to the Upper Gawib.

TABLE 3-33: VERTEBRATE HABITAT – PLAIN BETWEEN LANGER HEINRICH-WITPOORT

Habitat 8 - Plain between Langer Heinrich-Witpoort
Description: The hard, smooth surface, known as "desert pavement" is a very stable and structured substratum, established over many aeons. Shallow, sandy water courses that come off the west flank of the Schieferberg and cross the Plain between Langer Heinrich and Witpoortberg, which form the northernmost arms of the Tumas catchment. Small vertebrates dig burrows into the substrate, shelter under scattered dwarf shrubs, or find refuge and food under stones. **Occurrence in ML:** This forms the western section of the ML and is part of the gravel plain located north west of the Schieferberg and between the Langer Heinrich Mountain and the Witpoortberg. **Vertebrate groups**: This habitat is comprised of 15 mammal and 9 reptile species. Residents tend to be specialists to the relatively harsh conditions of such a parched, exposed landscape. **Sensitivity:** Sensitive community and habitat. **Vertebrate habitat determinants:** This area has the least resources for vertebrates in terms of food, water and shelter, but is home to a suite of desert specialists. Following rains, a flush of opportunists may appear temporarily. Small local disturbances, such as burrow systems of gerbils or digging by suricats, allow local pockets of vegetation to establish. Game animals traversing the area redistribute nutrients, removing it from some places (feeding), depositing it elsewhere in the form of faeces, and maintenance of game mobility is therefore important for the maintenance of ecosystem function. Shallow ephemeral pools may occur and support rarely-seen organisms. **Threats and restoration:** Off-road driving is more damaging in this plain compared to any other habitat. Mining activities may permanently destroy the desert pavement. Disruption of mobility of game will reduce the redistribution of nutrients. Animals living on the plains are most prone to become road kills. Heavy traffic causes extensive dust and noise pollution. The originally stable condition of the gravel plains may be impossible to recreate. Restoration may at best achieve recreating another kind of habitat.

TABLE 3-34: VERTEBRATE HABITAT – TUMAS WATERCOURSE

Habitat 9 - Tumas Watercourse
Description: Shallow, sandy water course that comes off the west flank of the Schieferberg and crosses the Plain between Langer Heinrich and Witpoortberg, are the northernmost arms of the Tumas catchment. Small vertebrates dig burrows into the substrate, shelter under scattered dwarf shrubs, or find refuge and food under stones. **Occurrence in ML:** A shallow water course crossing the Plain between Langer Heinrich and Witpoortberg in a north-westerly direction. **Vertebrate groups:** This habitat consists of 15 mammal and 9 reptile species. Focus of activity by plains-living vertebrates. Continuous habitat with the lower Tumas may allow near-coastal species to penetrate as far as LHU. **Sensitivity:** Highly sensitive community and habitat. **Vertebrate habitat determinant**s: Relatively more resources than the surrounding plains. Shrubs provide shelter and food. **Threats and restoration:** Blockage will constrain the habitat continuity of the Tumas and reduce population connectivity. Animals moving along the wash may cross the road and be killed. The drainage line can be re-established with a sandy floor and planting of hummocks, although this will take many decades to fully restore.

TABLE 3-35: VERTEBRATE HABITAT – SCHIEFERBERG SLOPE

Habitat 10 - Schieferberg slope
Description: This comprises mostly dark schist rocks in ridges or loose flakes/slabs, interspersed with small outcrops of quartzite, and local patches of quartz outcrops. The surface has very shallow and poorly developed soil. **Occurrence in ML:** The slopes projects into the ML and flanks the Shieferberg and Gawib Tributary **Vertebrate groups:** This habitat contains a moderate number of species of mammals (14) and reptiles (13), and a diversity of birds. Low population densities occur along the slopes. There is an occurrence of three reptile species of special conservation significance. **Sensitivity:** Ranges from a least sensitive to irreplaceable community and habitat. **Vertebrate habitat determinants:** The Schieferberg slope is the driest of all habitats, as rainwater quickly drains into the many deep cracks, where it is inaccessible. The substrate is generally very hard and difficult to burrow in. Overall productivity is low and temporary after rare rains. Some detritus accumulates in cracks and cavities, so that there is a basic resource base even during dry years. The dark colour of the rocks and the north-facing aspect render the surface hot and hostile during daytime. Small vertebrates find shelter in the many cracks in layers of schist, as well as under loose slabs of schist flakes. Shallow low caverns into cliffs are used as lairs, dens, roosts and nests. **Threat and restoration:** Mining has minimal effects in this habitat because of its large, continuous area, hard stable surfaces and low animal populations. Blockage of game corridors will reduce connectivity. There is need to establish how three reptile species of conservation significance will be impacted. Threat is low provided that destruction remains confined, and avoids the water courses and quartzite outcrops. Restoration would leave a surface more permeable than it currently is and productivity could perhaps increase above the current condition. Restoration should facilitate the reestablishment of the network of game trails by clearing the area and landscaping such that natural, frequent passage of zebra and klipspringer is again made possible. If quartzite outcrops are destroyed, conditions of thermal heterogeneity should be restored for reptiles of conservation significance.

TABLE 3-36: VERTEBRATE HABITAT – LANGER HEINRICH MOUNTAIN

Habitat 11 - Langer Heinrich Mountain
Description: The mountain itself falls outside the ML, but some of its foothills and water courses occur either inside, or along the northern border. **Occurrence in ML:** It comprises mostly quartzite. The Langer Heinrich Mountain is included because its enormous size dominates the surrounding environment and the occurrence of particular kinds of resources in the habitat affects adjacent biodiversity. **Vertebrate groups:** This habitat consists of 17 mammals and 12 reptiles, but these numbers are probably underestimated. More species can be found in the Gawib Tributary washes. The habitat is undisturbed and is an important local bastion for biodiversity. **Sensitivity:** Irreplaceable community and habitat. **Vertebrate habitat determinants:** Water pools, some of them deep and shaded, occur in steep water courses of the ML, and these cisterns still provide water to animals long after rainfalls. A fair amount of perennial vegetation represents food to many animals. Cracks and caverns in and under rocks and shade in ravines and overhangs make this habitat rich in refugia and provide water, food, safety, and shelter from the elements. **Threats and restoration:** The Langer Heinrich Mountain falls outside the ML and may not be directly disturbed, but its ecological functioning will deteriorate if connectivity with the Gawib Valley and Gawib Channel is severed and water courses are blocked or otherwise disturbed. Restoration of the Gawib valley floor and the Gawib Channel Acacia will restore the habitats connectivity.

TABLE 3-37: VERTEBRATE HABITAT – TINKAS MOUNTAIN

Habitat 12 – Tinkas Mountain
Description: These hills are relatively smooth without many steep cliffs, and there are only a few low rocky ridges and many loose slabs of schist strewn on the surface that provides limited shelter for small animals.

Habitat 12 – Tinkas Mountain
A few scattered quartzite outcrops occur. **Occurrence in ML:** The foothills to this mountain stretch along the entire eastern half of the ML, where they comprise undulating hills of schist and patches of quartzite. These hills are the south-western lip of Tinkas Mountain that extends across the south-eastern foot of Langer Heinrich Mountain. **Vertebrate groups:** This habitat is comprised of 18 mammals and 12 reptile species. There is a relatively high frequency of transient game animals. The Tinkas mountains together with the Gawib Tributaries appear to be of key importance as a zebra corridor. **Sensitivity:** Highly sensitive community and habitat. **Vertebrate habitat determinants:** There are few perennial plants and resource levels are low, except in pockets of quartzite ridges that dot these hills, where shallow water pans may linger after rains and perennial plants are denser. Game can readily traverse these undulating hills and be undisturbed and hidden away from the busy Gawib valley. A high degree of game traffic, based on tracks and trails, indicate that these hills are an important connection between places where different resources are located, e.g. water at one place, food at another, shelter at yet another. Water is known to occur in the Tinkas River located east. **Threats and restoration:** Blockage of connectivity in Tinkas mountain will disrupt zebra traffic and may cause loss of spatial memory of this area by zebra population. Connectivity needs to be restored. In case where rock dumps have been placed here, these should be smoothed and stabilised to the natural configuration of these foothills.

TABLE 3-38: VERTEBRATE HABITAT – FOOTHILLS OF SCHIST

Habitat 13 - Foothills of Schist
Description: Isolated hills are located North West of the confluence of Reid Wash and Gawib River, opposite the west flank of the ML. **Occurrence in ML:** The river channel is on the one side of the hills, and on the other side is the Plain between Langer Heinrich and Witpoortberg. The terrain has a few prominent ridges. **Vertebrate groups:** This habitat has low biodiversity consisting of 8 mammals, 8 reptiles. **Sensitivity:** Least sensitive community and habitat. **Vertebrate habitat determinants:** The Foothills of Schist is characterized by low productivity while ridges provide shelter for residents as well as users of the adjacent habitats. **Threats and restoration:** Mining activities or rock dumps may destroy this area. Restore as schist ridge.

TABLE 3-39: VERTEBRATE HABITAT – FOOTHILLS OF QUARTZITE BANK

Habitat 14 - Foothills of Quartzite Bank
Description: Slope of quartzite boulders. These slopes/hills form a relatively narrow strip between the Gawib channel and a sloping stony plain that separates the foothills from the main ML. **Occurrence in ML:** These are quartzite slopes that form the bottom terrace of the ML in the western part of the ML. **Vertebrate groups:** This habitat has a relatively low biodiversity of mammals (9), reptiles (13) but numerous bird species. **Sensitivity:** Highly sensitive community and habitat. **Vertebrate habitat determinants:** Except for the lack or paucity of water), these foothills are like a microcosm of the ML itself. These hills are difficult to traverse by game, but there are many refugia and shrubs that small vertebrates can use. **Threats and restoration:** Threats include dust and noise pollution from nearby mining activities and

Habitat 14 - Foothills of Quartzite Bank
possible inundation with waste rock dumps. Restore as quartzite ridge.

TABLE 3-40: VERTEBRATE HABITAT – FOOTHILLS OF CONGLOMERATE DEPOSITS

Habitat 15 - Foothills of Conglomerate Deposits
Description: The surface is a stony plain with sparse or very shallow soil, and the underlying calcrete is difficult to penetrate with burrows. **Occurrence in ML:** Western and Eastern calcrete conglomerate hills that form the lowest mountain terrace towards the centre of ML140, between GTS2&3. **Vertebrate groups:** This habitat has a very low biodiversity: 4 mammals, 2 reptiles. Some mammals use the overhangs of the Conglomerate foothills as shelter. **Sensitivity:** Ranges form a least sensitive to sensitive community and habitat. **Vertebrate habitat determinants:** The edges of these hills towards the Gawib valley or water courses form relatively open overhangs which vertebrates can use as temporary shelter. The ground is very hard and productivity very low. **Threats and restoration:** Currently used as waste rock dump. The area cannot be restored in its current form, but a smoothed hard surface would recreate its current conditions and allow passage from and to adjacent habitats.

TABLE 3-41: VERTEBRATE HABITAT – GRANITE KOPPIES

Habitat 16 - Granite Koppies
Description: The surface of the rock is rough, often with large partially separated flakes. Complex physical and chemical weathering has formed many cracks and holes and has sculptured the boulders and their surfaces as well the spaces between boulders into complex shapes. Soil is generally poorly developed except in horizontal bowls in the interior of these koppies. **Occurrence in ML:** These are located in the eastern quarter of the ML. Isolated hills of granite rocks and boulders, ranging in size from several hectares to 1 km^2, mark the north-eastern corner of the Schieferberg and occur along the border of the upper Gawib to the small Tinkas plains. An area of granite koppies in the very south east corner of the ML is where the Bloedkoppie Rock sculpture hiking trail is located, where the below-mentioned features can be appreciated by tourists. **Vertebrate groups:** This habitat consists of 17 mammals, 22 reptiles' species. Several ML species are only or mainly found on granite koppies or their boundary areas. **Sensitivity:** Irreplaceable community and habitat. **Vertebrate habitat determinants:** The granite koppies represent the highest level of complexity of space for vertebrates in terms of different-sized pockets bearing different resources particularly in terms of refugia and to a lesser extent food. The plains and small water courses immediately adjacent to these koppies benefit from the run-off and are particularly productive. These boundaries should therefore be seen together as part of the koppie complex. Detritus and dust has accumulated in holes and in cyanobacteria-encrusted ephemeral pools that form vegetation pockets. Granite inselbergs or outcrops are considered to be important if not key conservation havens in the Namib Desert as is generally the case in arid regions. The granite copies of the ML are no exception. **Threats and restoration:** Pollution and physical destruction are the main threats. A study should be conducted regarding the significance of this area for animals. If restoration is possible, some species will need to be reintroduced onto isolated koppies.

TABLE 3-42: VERTEBRATE HABITAT – SANDY PATCH AT WESTGATE

Habitat 17 - Sandy Patch at Westgate
Description: Sand blown by east-wind has over aeons steadily accumulated on the lee slope of a Schieferberg foothill at this location. This sandy patch could be unique in the ML, but similar isolated sand patches are found at mountains elsewhere in the Namib. Although the Westgate Sand Patch is small, the

Habitat 17 - Sandy Patch at Westgate
sand is well established, semi-stable, and forms a distinct habitat. **Occurrence in ML:** These are located on the lower Schieferberg towards the middle of the ML on the southern side, next to a LHU leach tank close to the West gate of LHU. **Vertebrate groups:** This habitat has a high biodiversity for such a small area: 8 mammal and 8 reptile species. This is the only site where three species of Sand Lizards and the Husab Sand Lizard were actually observed. Porcupines dig up lily bulbs that grow in the moist sand. Sand-living (psammophilous) species are found here that were not observed in the rocky surroundings of this patch nor in the wash at its base and some that were collected here were not seen elsewhere on the ML. Small vertebrates sand-swim and burrow into this small dune, or dig into the sand for food. **Sensitivity:** Irreplaceable community and habitat. **Vertebrate habitat determinants:** Rocky ridges surrounded by unconsolidated sand offer patchy microhabitats, increasing heterogeneity. Sand is moisture-retaining, which can benefit burrowing animals. Surface water will not accumulate after rain. **Threats and restoration:** Uncontrolled process plant development can permanently destroy this patch. This takes aeons to establish ecologically and for animals, like the porcupine, to get to know the location when foraging. There is a possibility of rehabilitating a small sandy patch and reintroducing fauna. It is recommended to fence this area towards the mine side and leave it open to the Gawib tributary washes and to merely remove the fence when the mine closes.

TABLE 3-43: VERTEBRATE HABITAT – QUARTZITE OUTCROPS

Habitat 18 - Quartzite Outcrops
Description: Quartzite outcrops are areas of tens of metres in extent. They are of lighter colour and with more complex topography than the surrounding schist slopes, and some soil and ephemeral pools can form on them. **Occurrence in ML:** This habitat is embedded in the schist rock habitats of Schieferberg and Tinkas Mountain. The current study could not undertake a detailed study of locations of all quartzite outcrops on schist. If found, the location of quartzite outcrops should be marked. **Vertebrate groups:** This habitat is an important area for juvenile sand lizards, including several species of conservation significance. There are rare places on schist hill slopes where ephemeral pools can form. A lot of the biodiversity described for the Schieferberg slopes and Tinkas Mountain has its focal points on quartzite outcrops, not only for sand lizards, but also other mammals such as porcupines, which are found nowhere else on the Tinkas Mountains. **Sensitivity:** Irreplaceable community and habitat. **Vertebrate habitat determinants:** The quartzite outcrops are characterized by lighter-coloured topographically complex surface that represents microclimatic islands on hot and dry surroundings. Impermeable rock can form bowls where water persists for longer than in the surrounding habitat. Patches of soil are more developed than in surrounding areas, harbouring some burrowing animals. Schist hillsides are probably more habitable because of these habitat nodes. **Threats and restoration:** The destruction by mining-related activities will have a disproportionate effect on the biodiversity of surrounding areas. Although it is considered impractical, if not impossible to rescue all vertebrates populating of the habitat, an effort should be made to remove them and release them at replacement sites. The re-establishment of lighter-coloured topographically complex rocky slopes on darker surroundings with smoother surfaces is recommended. The local water-holding function can be restored by cementing some of the re-established outcrops. Layers of soil should be added in patches so as to recreate the heterogeneity of quartzite outcrops. In case an outcrop is destroyed, research should determine how to repopulate a new outcrop with typical residents.

TABLE 3-44: VERTEBRATE HABITAT – EPHEMERAL POOLS

Habitat 19 - Ephemeral Pools
Description: Temporary pools linger for short periods after rainfall in the riverbed and in shallow bowl-like

Habitat 19 - Ephemeral Pools
depressions within granite koppies and also on the open plains with base of flat rock or calcrete. **Occurrence in ML:** This habitat is embedded in other habitat types. On the ML, sites with ephemeral pools were found in the granite koppies and on the flanks of Langer Heinrich Mountain and Tinkas Mountain. The current study could not undertake a detailed study of locations of ephemeral pools in the plains within the limited timeframe, but such places are known from nearby areas (e.g. Tinkas plains south of Gawibberg). If found, the location of ephemeral pools should be marked. **Vertebrate groups:** This habitat is comprised of 2 frog species. Numerous mammals, reptiles and birds drink from these pools. **Sensitivity:** Ranges from a highly sensitive to irreplaceable community and habitat. **Vertebrate habitat determinants:** Although ephemeral pools are seldom seen, the fact that water outside of rivers always pools at the same place after rainfall even with intervening periods of years means that animals such as frogs and fairy shrimps that endure the drought in suspended animation (aestivating) at such places, can swim, feed and reproduce in water following rain. **Threats and restoration:** Mining activities, roads, dust pollution are the main threats towards this habitat. These pools are too rare in space and time to be able to establish the consequences of some patches disappearing from the metapopulation, and immediate compensation is recommended, and should be established before the next rain. If destruction cannot be avoided, then the topsoil and any aestivating individuals should be carefully kept and re-established at a nearby alternative site that would be suitable for a future new ephemeral pool (this may require some landscaping). Before development is undertaken on plains, locations of ephemeral pools need to be established. These places and their immediate surroundings should be protected from destruction at all times if at all possible.

3.9. RADIOLOGICAL

Information in this section was sources from the specialist radiological study attached in Appendix O (NECSA 2009).

No information is available on the pre-mining or current radiological situation relating to biodiversity (natural vegetation, vertebrates and invertebrates). Moreover, this field is not well understood and further research is required in general.

Four pathways are relevant when considering the environmental radiological components in the context of potential human health impacts. These include:

- direct external exposure to radiation;
- aquatic pathway through radio-nuclides that are carried in surface and groundwater;
- atmospheric pathway through radon gas and radio-nuclides in dispersed dust; and
- secondary pathways including ingestion of contaminated soils, radiation from contaminated soils, the eating of crops that are grown on radioactive contaminated land/soil and/or eating radioactive contaminated fish and/or animals (livestock).

Discussion on the various aspects is provided below.

3.9.1. DIRECT EXPOSURE TO RADIATION

In the context of the natural environment, radiation can occur from natural sources such as cosmic and terrestrial radiation. The recorded natural baseline (pre mining) gamma radiation doses at the ML relate to public doses of between 0.5 and 4.3 milli-Sievert per annum (mSv/a) (NECSA 2009) in a scenario where people are situated on-site and within close proximity (on or next to) to the radiation sources for approximately 8 hours a day over an extended period (eg. 1 year).

In the context of the mine, radiation typically originates from mineralised substances (ore, mineralised waste, uranium product) and radioactive non-mineralised waste in the form of alpha radiation, beta radiation and/or gamma radiation. Typically, radiation doses of approximately 0.01 mSv/a will not be exceeded more than 500m from these sources (NECSA 2009). This is significantly less than the annual recommended dose limit of 1mSv/a (from all sources excluding medical and natural sources) that third parties should be exposed to (International Atomic Energy Agency (IAEA), 2004 as interpreted by NECSA 2009).

3.9.2. AQUATIC PATHWAY

Ongoing monitoring and analysis of groundwater quality has been conducted from prior to mining and the relevant discussion on the radiological component is provided as part of the groundwater discussion in Section 3.11.2. No information is available for surface water, which is an infrequent occurrence as discussed in Section 3.10.

3.9.3. AIR PATHWAY

Radiological issues relevant to air quality monitoring and analysis are discussed in Section 3.12 as part of the discussion on air quality.

3.9.4. SECONDARY PATHWAYS

No information on either the pre-mining or current radiological situation is available for soils within or outside the ML, or for farm related foodstuffs (crops and livestock) on farms in the region (further discussion on the farming areas is provided in Section 3.16.6).

3.10. SURFACE WATER

This information in this section was sourced from the specialist hydrology study attached in Appendix F (Metago 2008) and should be read with reference to Figure 3-1.

3.10.1. SURFACE WATER DRAINAGE

The Gawib and Tinkas Rivers influence water flow in and adjacent to the ML. Both of these rivers flow into the Swakop River north of the Langer Heinrich Mountain. The Tinkas River and related tributaries drain the far eastern end of the Valley, while the Gawib River and related tributaries drain the central and western end of the valley. The rivers are ephemeral which means that they are normally dry on surface but occasionally flow immediately after heavy rainfall events. Two significant rainfall events have been observed on site in the past three years. During these two events surface water from the Gawib River reached the confluence of the Gawib and Swakop Rivers. Subsurface water is present in the larger rivers for longer periods. More detail on the subsurface water is provided in section 3.11 of the EIA report.

The existing approved LHU infrastructure and activities are located within and/or immediately adjacent to the Gawib River and related tributaries. The probabilistic calculation of flood events (Metago 2008) for the Gawib catchments has provided LHU with guidance on flood management and protection of key infrastructure. The use of the open upstream pit A (located to the east of the current processing plant and mining areas) as a storm water catchment facility is an important factor in this regard. It has the capacity to contain more than the calculated 1 in 100 year flood event of 44mm which amounts to approximately 2,500,000m^3 of water. In addition, flood protection measures for the temporary tailings facility and tailings delivery pipeline have been implemented. Additional discussion on the current infrastructure and activities is provided in Section 4.

New infrastructure associated with the proposed expansion project has mostly been located outside of river channels on the western plains and Schieferberge foot slopes. In this regard, the proposed heap leach pad, satellite crushing plant, temporary contractors camp and mine workshop are all located more than 150m from the Tumas wash/tributary and 500m from the Reid wash/tributary. Further detail and infrastructure layouts are provided in Section 6.

The proposed modifications to the existing processing plant are located within the current plant boundary which is within the Gawib River flood area. In addition, parts of the proposed additional power supply to the Swakop River boreholes are located in the Gawib and Swakop River flood areas, and the proposed utilities (power and pipelines) between the current plant and proposed new infrastructure to the west will have to cross the Reid wash/tributary in the same manner as existing power and pipelines.

3.10.2. SURFACE WATER QUALITY AND USE

The use of limited temporary surface water pooling (mainly after heavy rains) both up and downstream the ML is restricted to the various ecosystem functions. No human communities make use of this surface water. The lack of surface water occurrences in the vicinity of the ML means that no surface water samples have been taken to analyse and trend surface water quality.

3.11. GROUNDWATER

Information in this section was sourced from the specialist groundwater study included in Appendix J (BIWAC 2009).

3.11.1. AQUIFER DESCRIPTION

Groundwater exists around five identified geological zones (see Table 3-1 in Section 3.1):

- The shallow alluvium – this zone is mostly dry but carries water after rainfall or seepage events. Water flow follows topography. There may be vertical seepage to underlying aquifer zones.
- The upper calcrete layer – this zone is less permeable, is mostly dry and may form a barrier to vertical flow in some areas.
- The lower calcareous paleo-channel sediments – this zone is mostly dry and acts as a semi confining layer that may be recharged from above through fractures and fissures.
- The basal paleo-channel – this zone carries most of the groundwater into and out of the ML. It is recharged from below and may also be recharged from above zones in places.
- The basement rocks – this zone incorporates very low permeability rocks. If fractures and faults exist there will be some linear flow.

Three of these layers are considered aquifers: the shallow alluvium, paleo-channel and basement. The paleo-channel, in which the Langer Heinrich deposit is situated, occurs both within the Gawib River and extends westwards beneath the Gawib Plain (see Figure 3-1). In the Gawib River valley, where current mining operations take place, small isolated perched water tables occur between 5 and 50 m depth, while in the higher elevated plateau area, located to the west of the current mining operations, the water level is between 30 and 60 m.

Flow directions for each aquifer are as follows:

- flow in the alluvial aquifer follows the Gawib River to the north west and then follows the Swakop River to the west (see Figure 3-1 for the orientation of the Gawib and Swakop Rivers);
- flow in the paleo-channel aquifer is towards the west and it is then expected to make its way to the Atlantic Ocean (see Figure 3-12);
- flow in the basement rocks will be determined by fractures and faults. These fractures and faults are not fully understood but it is expected that the flow is also to the north west (see Figure 3-13).

FIGURE 3-12: GROUNDWATER FLOW DIRECTION IN THE PALEO-CHANNEL AQUIFER

FIGURE 3-13: GROUNDWATER FLOW DIRECTION IN THE BASEMENT ROCK

3.11.2. GROUNDWATER QUALITY

The natural (pre-mining) groundwater within and outside of the ML is generally of poor quality with various parameters, including naturally occurring uranium, being measured at levels above those recommended by the World Health Organisation for drinking water (WHO, 1984). Pre-mining water quality for selected parameters that have been compared to both the WHO and Namibian drinking water quality guidelines (Water Affairs, 1988) is provided in Table 3-45 (further detail is provided in the groundwater specialist report - Appendix J). The borehole locations are indicated on Figure 3-1.

TABLE 3-45: PRE MINING GROUNDWATER QUALITY

Selected Parameters	WHO Guideline & Namibian Group A & B Guideline	Selected Boreholes						
		WW41181	WW41182	WW41180	WW41189	LH1049	LH1004	LH1177
Total dissolved solids (TDS) – mg/l	1000 No guideline	6958	9210	3975	1445	7208	12938	9345
pH	6.5 to 8.5 6 to 9	7.1	7.1	7.2	7.4	7	6.9	6.9
Chloride (Cl) – mg/l	250 250 to 600	3230	3905	1856	522	3468	5582	4347
Sulphate (SO_4) –mg/l	250 250 to 600	771	1151	460	252	628	1743	780
Uranium (U)- mg/l	0.015 1 to 4	0.06	0.11	0.06	0.011	0.12	0.18	0.11

The elevated off-site (boreholes WW41180, 81 and 82) pre-mining uranium concentrations are associated with a calculated effective radioactive dose (if people make regular use of this water in a given year) of approximately 0.16 milli-Sievert per annum (mSv/a) (NECSA 2009). This is less than the annual recommended dose limit of 1mSv/a (from all sources excluding medical and natural sources) that third parties should be exposed to (International Atomic Energy Agency (IAEA), 2004 as interpreted by NECSA 2009). Potential radioactive doses associated with the natural groundwater quality are higher in close proximity to the mineralised deposit within the ML.

Within the ML, seepage from the temporary tailings storage facility (TSF) has caused a localised pollution plume in the shallow alluvium. The plume contains elevated concentrations of various parameters including uranium (further detail is provided in BIWAC 2009). The plume is currently controlled by a 12m deep cut-off trench called the western trench (which intercepts seepage), from where the seepage is contained and pumped back to the plant. No groundwater pollution has been measured beyond the trench or outside the ML.

3.11.3. GROUNDWATER USE

There is no reliance on localised groundwater resources by humans in or adjacent to the ML. Localised groundwater is however important for ecosystem functionality. Further afield, certain people's livelihoods are dependent on groundwater that is abstracted from the Swakop River and the fractures in the basement. Farmers located 50km downstream of LHU (downstream of the confluence of the Khan and Swakop Rivers) abstract water from the Swakop River alluvial aquifer and use this to irrigate crops as a supplement to the potable water that they obtain via pipeline from Swakopmund. Farmers located 15km and further to the north of LHU, abstract water from fractures in the basement rock for both domestic use and livestock watering (see Figure 1-2).

3.12. AIR QUALITY

Information in this section was sourced from the specialist study included in Appendix G (Airshed 2009).

Identification of existing sources of emissions in the region and the characterisation of existing ambient pollution concentrations is fundamental to the assessment of cumulative air impacts. To date, little work has been done to collect monitoring data or to compile an emissions inventory for the relevant part of the Erongo region. The air study therefore focused on identifying sources and pollution types in the region that may be important from a cumulative impacts perspective. The relevant information is included in Table 3-46.

TABLE 3-46: REGIONAL AIR POLLUTION SOURCES AND TYPES

Sources	Pollution types
Mining/processing operations	In general mining/processing operations have the potential to emit a number of pollution types. The most significant is the dust (the smaller inhalable particulate matter and larger suspended particles) with smaller quantities of oxides of nitrogen, carbon monoxide, sulphur dioxide, methane and carbon dioxide. In addition, uranium mines are associated with the emission of radon gas and the emission of radio-nuclides as part of the particulate matter and suspended particles. Given the standard controls that are often used to manage these pollution types, the emissions are usually only of concern within approximately 3km of the mine sources. Given that Rossing is the closest mine to LHU (approximately 40km away), it is too far away to impact on the ambient air quality in the vicinity of LHU.
Vehicle tailpipe emissions	The primary pollutants emitted by vehicles include oxides of nitrogen, carbon monoxide, sulphur dioxide, carbon dioxide, hydrocarbons, particulate matter and lead. Vehicles using the LHU access road will contribute to the ambient air quality in the LHU vicinity. Vehicles using the C28 may also contribute to the ambient air quality, but this impact is less clear because like for mining sources, the vehicle tailpipe sources also have localized dispersion.
Agriculture activities	All agricultural activities have the potential to emit dust. Depending on the methods used, livestock farming (in particular feedlot type farming) has the

Sources	Pollution types
	potential to emit dust, methane, ammonia and hydrogen sulphide. Given that farms are located more than 15km from LHU and that the livestock farming methods are more traditional (take place on large farms without feedlots), there is unlikely to be a significant contribution from these sources to the ambient air quality in the vicinity of LHU.
Biomass burning	Where wild fires and crop burning occur they emit carbon monoxide, methane and oxides of nitrogen. The vegetation cover in the LHU region is considered too sparse to be a significant source.
Miscellaneous fugitive sources such as vehicle entrainment of dust, and windblown dust.	Given the proximity of the road network and the nature of the desert environment, external dust sources will impact on the ambient air quality in the vicinity of LHU. This has not been quantified.

Of some relevance is the fact that LHU has commenced with a dust fallout monitoring programme. Information from the first two months of monitoring indicates that localised fallout of the larger suspended dust particles (TSP) within the ML is generally high when compared to the industrial (1200mg/m2/day) and residential (600mg/m2/day) South African dust fallout guideline (sourced from Airshed 2009).

Initial natural baseline (pre-mining) radon gas monitoring indicated the potential for on-site doses (if the same people are exposed on a daily basis in any given year) ranging between 3 and 11 mSv/a in the scenario where exposure is 50% indoors and 50% outdoors (NECSA 2009). It must be noted that the data is incomplete and should therefore only be used indicatively. Subsequent radon monitoring that has been conducted by LHU indicates that doses (if the same people are exposed on a daily basis in a given year) at areas such as Bloedkoppie and the temporary tailings facility range between 0.6 and 1 mSv/a respectively (NECSA 2009). When considering third party exposure, there is some international debate about the relevant dose limits for radon gas and therefore the annual recommended dose limit of 1mSv/a (from all sources excluding medical and natural sources) is considered relevant in the context of this EIA (International Atomic Energy Agency (IAEA), 2004 as interpreted by NECSA 2009).

The environmental monitoring programmes for smaller inhalable dust particulates less than tem micron in size (PM10), for radioactive components of the TSP and PM10, and for radon gas emission sources are being commissioned. These environmental monitoring programmes will augment the radon gas and radiation monitoring that LHU currently undertakes from an occupational health and safety perspective.

3.13. NOISE

Existing frequent noise sources within and around the ML include:

- natural sounds from wind, vertebrates and invertebrates;
- vehicle movement on the public road network; and
- LHU activities, in particular: blasting, vehicle movement, materials handling and generators.

In general, the noise environment outside of the ML is typical of a wilderness environment. The mountainous topography around the ML assists with containing mine related noise.

3.14. HERITAGE RESOURCES

Information in this section was sourced from the specialist study included in Appendix K (Kinahan 2009).

As a general comment, the Namib Desert has a long archaeological record that dates back approximately 800 000 years. Part of this record reflects a series of human occupations of the desert, mainly in response to climate trends.

In this context, the baseline study for the EIA was built on previous reconnaissance survey efforts. The combined studies identified a range of archaeological sites mainly concentrated around the granite outcrops at the eastern end of the ML (see Figure 3-14 and the specialist report in Appendix K for a full description of each of the individual sites).

Most of the identified sites relate to the occupation of the Namib in the second millennium AD by hunter-gatherer communities. These communities are believed to have existed in the area subject to water availability and conducted the following activities:

- gathering of wild grass seed from the underground caches of harvester ants;
- hunting; and
- honey harvesting.

The ML and adjacent ground also contains some sites relating to combat in 1915 between the German forces and the invading South African forces under General Louis Botha. The identified sites include:

- artillery positions made from stone walls;
- military dump sites;
- trenches; and
- graves

Most of the more significant and sensitive sites are located outside of the ML. The rest of the sites are considered to have medium sensitivity which indicates that they are relatively minor sites which form a meaningful local distribution and may have associated research potential.

FIGURE 3-14: ARCHAEOLOGICAL SITES

3.15. VISUAL LANDSCAPE

Information in this section was sourced from the specialist study included in Appendix L (NLA 2009).

In describing the visual landscape a number of factors are considered, including: landscape character, sense of place, aesthetic value, sensitivity of the visual resource, and sensitive views. Each of these concepts is discussed below.

Landscape character

The natural landscape surrounding the ML is rugged, scenically beautiful and peaceful. Key related aspects are:

- the lack of human activity and structures because the ML is in the Namib Naukluft Park;
- the related peace and tranquillity associated with the general quiet that is punctuated by natural sounds;
- the contrast between mountains, valleys, plains, and river channels;
- the contrast of dark and lights colours; and
- the mix of arid and vegetated areas.

Within the ML, along the road routes and to a lesser extent along the pipeline route to the Swakop River, the landscape is disturbed by mining activities and infrastructure with the associated visual and noise intrusions.

Sense of place

Central to the concept of sense of place is that the landscape requires uniqueness and distinctiveness. It is the extent to which a person can recognise or recall a place as being distinct from other places – as having a vivid and unique character of its own.

The sense of place of the natural environment is directly linked to the landscape character. In this regard, the natural sense of place is significant, but the sense of place within and close to the ML and road route has been compromised.

Aesthetic value

An area is considered to have more aesthetic value if it contains greater landscape diversity (more distinctive features). This diversity covers form, line, texture and colour. In addition, the value decreases with man-made interventions in the form of activities and structures.

In this context, mountains and rivers have greater value, gravel plains have moderate value and the mining area has low value.

Sensitivity of the visual resource

The sensitivity of the visual resource is the degree to which a particular landscape can accommodate change from development without detrimental effects on its character. In this regard, the natural landscape of mountains and river valleys is highly sensitive to change.

Sensitive views

The sensitivity of visual receptors and views are dependent on the location and context of the viewpoint, the expectations and activity of the receptor, the view's appearance in books and maps, and references to the views in literature and art.

Around the ML the most sensitive views are:

- from Bloedkoppie;
- from the wilderness area to the east of the ML; and
- in the vicinity of the Swakop River and the battlefield sites to the north of the ML.

3.16. SOCIO-ECONOMIC STRUCTURE/PROFILE

Information in this section was sourced from the specialist studies included in Appendix M (Hoadley 2009) and Appendix N (Metago Strategy4Good 2009).

3.16.1. REGIONAL SETTING

The regional setting of the ML is included in Table 3-47 and illustrated in Figure 1-1 and Figure 1-2.

TABLE 3-47: REGIONAL SETTING

Region	Erongo Region
Local authorities	Erongo Regional Council; Swakopmund and Walvis Bay Municipalities
National authorities	MET – Parks and Wildlife
Project location	Namib Naukluft Park
Closest towns/communities	Farmers ~15km to the north, Swakop River farmers ~50km to the west, Swakopmund ~90km, Walvis Bay ~90km and Arandis ~50km.
Catchment	Swakop River

3.16.2. REGIONAL SOCIAL ENVIRONMENT

Erongo is Namibia's sixth largest region, extending over 63,720 km^2. The population in 2007 was estimated at 111,346 with a yearly growth rate of 1.3%. The region is sparsely populated, and its inhabitants are widely dispersed, resulting in a very low population density.

Most of the population is found in urban areas with a majority living in the towns of Walvis Bay, Swakopmund, Omaruru, Karibib, Arandis, Usakos, Uis and Henties Bay. There are a few communities that are located outside of these urban areas. In this regard, there is the Swakop River farming community and a Topnaar Nama community. The latter is located along the Kuiseb River between 80 to 100km from the LHU ML. The Topnaar is one of the oldest inhabitants of the Namib desert and earliest records date back to 1670. Traditionally the Topnaar Nama of the lower Kuiseb Valley lived by herding cattle, gardening and gathering the nara (*Acanthosicyos horridus*). They were nomadic, restricted only by the availability of waterholes within the Kuiseb River and the nara distribution. In 1907 the Namib Naukluft Park was declared and the presence of the Topnaar within the Namib Naukluft Park has been controversial.

Erongo is considered to have some of the best schools in Namibia. There are 45 state schools in the region, and 13 private schools. Adult literacy rates are high compared to the national average: 92% of 15+ years are literate. Remote rural areas display lower literacy rates than urban areas.

Health services in the region are relatively good. The construction of new health facilities has brought health services closer to the communities. There are state hospitals in Omaruru, Usakos, Swakopmund and Walvis Bay. Swakopmund and Walvis Bay have a private hospital each, and clinics serve both the urban and rural population. Fertility and mortality rates indicate that life expectancy in Erongo is higher than the national average, while infant and under-five mortality rates are lower.

Notwithstanding Erongo's relatively good position in Namibia, the socio-economic status varies from the extremely poor to the wealthy. This translates into a significant range in living standards with the poorer part of the population being exposed to greater challenges in regard to schooling, medical care, employment and the social and economic impact of HIV/AIDS and tuberculosis.

3.16.3. REGIONAL ECONOMIC ENVIRONMENT

After the Khomas Region, the Erongo Region has the second highest income per capita in the country. This relative prosperity is based on fishing, mining and tourism. All three sectors are important in that they:

- are all significant contributors to the Erongo regional economy and the Namibian Gross Domestic Product (GDP);
- all earn Namibia significant foreign exchange;
- all provide significant employment opportunities;
- all require both goods and services from other sectors which implies significant economic multiplier benefits; and
- all have potential for future growth.

The main economic activities in the Erongo Region are concentrated in the two coastal towns of Walvis Bay and Swakopmund, as well as the surrounding mines and exploration operations. The smaller towns offer limited employment opportunities, while opportunities in agriculture, small-scale farming and tourism are scattered widely throughout the region. In this regard, Swakopmund and Walvis Bay comprise more than 50% of the region's economic base, and they contribute more than 25% to national GDP.

It follows that there is significant in-migration of people to Walvis Bay and Swakopmund in particular. People migrate to these areas for various reasons, but two of the more common reasons are to seek jobs and to establish businesses. The sectors that attract these people are mining, tourism, fishing and to a lesser extent agriculture.

3.16.4. LAND USE IN THE REGION

The three most significant land uses in the Erongo region are conservation/tourism, agriculture and mining.

Conservation/tourism

Much of the Namib Desert falls within conservation areas, and National Parks account for almost a third of the land use within the Erongo Region. These areas include The Namib section of the Namib Naukluft Park and the National West Coast Tourist Recreational Area.

Agriculture

Areas of the Central Namib Desert which have not been proclaimed as conservation areas usually have no surface water and little or no available groundwater. Consequently, they are generally of very low agricultural potential and cannot support formal farming activities. Two types of farmers are active in the Erongo Region: communal farmers and commercial farmers. Communal farmers are involved in small-scale production for own consumption or for sale at the local, often informal, markets. The following aspects of commercial farming could be found in the Erongo region:

- livestock, i.e. both small and large stock,
- game, and
- irrigation, i.e. vegetables, grapes and citrus.

Farms located on the lower portion of the escarpment/desert transition are considered totally unsuited to any farming practice. Nearer the coast, formal farming is undertaken on several small holdings in the lower Swakop River. Dairy and vegetables are produced here for the local market. Towards the interior portion of the Central Namib Desert, informal farming was conducted along the courses of most of the rivers and still continues along the rivers to the north of the Swakop River. Several groups of Topnaar raise goats, cattle and donkeys along the lower reaches of the Kuiseb River.

Mining

Mining activities account for a significant portion of land-use in the Erongo Region. According to the Ministry of Mines and Energy, as at 1 September 2006, approximately 114 licences and/or Exclusive Prospecting Licences were registered or pending with the Ministry, though most of these have not yet been activated. The main commodities mined are uranium and gold. Extensive salt mining also occurs along the coast at Walvis Bay. Prior to the start of mining operations at Rössing Uranium, several small- to medium-scale prospecting and mining operations were located in the Central Namib region, focusing mainly on copper, tin and semi-precious stones.

Small-scale mining is an important economic activity in the region. A total of 521 claims were registered or pending with the Ministry of Mines and Energy as at 1 September 2006. The main commodities are semi-precious stones, dimension stone and tantalite-cassiterite.

3.16.5. LAND USE IN THE ML

Land surface rights in the ML, as part of the Namib Naukluft Park, are owned by the Namibian Government care of the MET – Parks and Wildlife. The ML provides LHU with the right to conduct approved activities associated with the mine in the designated areas. There are no known servitudes or other land encumbrances in the ML.

3.16.6. LAND USE SURROUNDING THE ML

This section should be read with reference to Figure 1-1, Figure 1-2, and Figure 6-1.

Land immediately surrounding the ML is used for conservation, eco-tourism and mineral exploration activities. In this regard, the ML (47km^2 in extent) and the immediately surrounding land is located in the Namib Naukluft Park (50 000km^2 in extent). A small piece of land within the Park, close to the current LHU abstraction borehole WW41183, is privately owned (see Figure 1-2). This land is referred to as the Riet Farm and although it can never be developed, the owner has access to the land for camping and other non-intrusive activities.

There are no communities living in the vicinity of the ML. The closest communities are:

- farms to the north – the closest inhabited farm is called Modderfontein and is situated approximately 15km north of the ML;
- the Swakop River farming community – approximately 50km downstream of the ML
- Arandis – approximately 50km from the ML;
- Swakopmund – approximately 90km from the ML;
- Walvis bay – approximately 90km from the ML; and
- The Topnaar Nama nomadic community – along the Kuiseb River between 80 to 100km from the ML.

There are a number of significant tourist attractions within the Namib Naukluft Park within the same region as the ML. The closest of these is Bloedkoppie (approximately 7km from the current operations and approximately 1km from the eastern ML boundary), the wilderness area to the east of the ML, some German graves (approximately 10km away from current operations), and the remains of a second world war battle field near the pipeline route at the Swakop River (approximately 15km from the ML). Further afield (approximately 30 to 50km) the Welwitschia plains and the Moon landscape are popular attractions.

A network of roads exists within the project area. These include:

- the C28 that runs through the Namib Naukluft Park and links Swakopmund to Windhoek;
- the LHU access road off the C28 that leads to the mine;
- The LHU access road to the Swakop River boreholes; and
- various smaller unnamed gravel roads and tracks.

The NamWater pipeline (and related servitude) runs alongside the C28 for about 50km and then branches off to follow the LHU access road to site. The section of water pipeline adjacent to the C28 is located above ground, whilst the section adjacent to the LHU access road is underground. The powerline servitude to LHU runs from the Kuiseb Substation straight to the LHU access road, from where it runs parallel with this road to the operations.

There is also an above ground water pipeline and associated gravel track between the Swakop River boreholes and the ML running alongside the Langer Heinrich Mountains towards the operations area.

There are a number of other mining and mineral exploration companies in the region that are engaged in either exploration, construction and/or operational activities. Those closer to LHU include:

- Rössing Uranium Limited (operational);
- Extract Resources (exploration and feasibility phase);
- Reptile Mining (exploration);
- Bannerman Resources (exploration & feasibility phase);
- Areva Resources Namibia/Trekkopie (construction);
- The Forester Group/Valencia (ML awarded but not yet in construction phase); and
- Nova Energy (exploration).

4. CURRENT APPROVED ACTIVITIES AND INFRASTRUCTURE

4.1. OVERVIEW OF CURRENT APPROVED ACTIVITIES AND SURFACE INFRASTRUCTURE LAYOUT

The current approved LHU infrastructure and activities are presented in Table 4-1. Reference should be made to the layout on Figure 4-1 and the flow diagram on Figure 4-2 when reading this section.

TABLE 4-1: SUMMARY OF CURRENT/APPROVED LHU INFRASTRUCTURE AND ACTIVITIES

Infrastructure	Description
Access Road	• The access road to the mine joins the regional C28 road. All employees, contractors, input materials, waste materials and product that are transported to or from site, are transported on the access road and C28. From the C28 the traffic flows are split between the roads to Walvis Bay, Swakopmund and Windhoek.
Airstrip	• A 1.3km gravel runway is located on the gravel plains on the western side of the ML, about 300m north of the access road.
Barren stockpiles	• There are two barren stockpiles (rejected from the processing plant). One east of the process plant and the other south of the one waste rock dump.
Exploration (driller's) camp site	• An exploration drilling contractor camp is located in the south east of the ML approximately 5km from the processing plant. Approximately 30 people stay there for 4 days a week.
Contractor lay-down area	• This is a site that is used to accommodate any short term contractors. It consists of a yard with storage and ablution facilities. These ablution facilities discharge into a French drain system. It is located within the ML to the west of the process plant and was part of the original construction camp
Conveyors	• Conveyors are used to transport material in the front end of the process plant between the crushers, scrubbers and some of the stockpiles.
Exploration drill rigs and network of boreholes	• Exploration drilling is continuous. It is used to upgrade the mineral resource on a yearly basis as well as to assist with detailed mine planning.
Explosives	• The explosives compound is located on the eastern side of the current temporary tailings storage facility (TSF) and is accessed by a single controlled-access road. It houses heavy energy fuel (HEF) storage tanks and an unloading bay. There are two fenced in explosives magazines. Management of the explosives compound and of all blasting activities is currently subcontracted to Bulk Mining Explosives (BME).
Fuel storage facilities	• There are a number of above ground diesel and petrol fuel tanks located in covered and/or bunded areas.
Internal haul roads	• There are a number of internal dirt haul roads within the ML. Trucks are used to haul run of mine (ROM), mine residue waste and other equipment and material.
Laboratory	• Samples of solids, liquids, pulp and resin from the processing plant are analyzed at the assay laboratory. • Analyses includes: ▪ XRF (Uranium & Vanadium mainly) ▪ Ore Moisture ▪ Titrations ▪ Total suspended solids • The laboratory is also equipped for analysis of environmental (dust and water) samples. The results from the analyses are used for process control, metal accounting purposes and water quality monitoring. Any excess sample volumes are returned to the process before the sample containers are cleaned out for re-use.
Low grade	• Currently low grade ore material (discard from the open pits) is stockpiled to the

Infrastructure	Description
stockpiles	east of the processing plant. Provision has been made for additional stockpiles in the ML, as required.
Offices, stores and Workshop	• The main office complex (offices and ablution facilities) is located within the security fence directly north of the processing plant. • An engineering office block is located between the process water dam (process dam) and the Engineering workshops. Activities associated with the workshops include painting, grinding, welding, repairs and general maintenance. • The front end process control room is located inside the laboratory building, which is situated near the counter current decantation (CCD) tanks in the plant area. The back end central process control room is located in the recovery building. • Karibib mining contractors has its own office and workshop, with a fuel storage facility and tyre workshop, directly east of the main office complex. • In relatively close proximity to the engineering workshop, there is an engineering storage yard for new large equipment and salvageable equipment. • The following items are kept at the store: reagents - sodium carbonate; sodium bicarbonate; sodium chloride; flocculent; hydrogen peroxide; sodium hydroxide; sulphuric acid; and ferrous sulphate, personal protective equipment, paint, and general maintenance equipment.
Open pit mine	• Mining is performed using conventional open pit mining methods. • In accordance with current approvals, the dimensions of the total mined area will be in the order of an 11.5km (east-west) long pit, plus a number of smaller pits over an additional 4.0km. The average width (north-south) will be 400m, and the average depth will be 30m, although the deepest point will be 80m below the ground surface. • Current mining areas include Pit A, Pit B and Pit D. These are situated north-east and west of the processing plant.
Open pit dewatering facilities	• Water seeping into the pits is pumped via pipelines to dedicated water storage areas to be used for dust suppression or for use as process water in the plant.
Ore stockpiles (ROM)	• The mined out ore grade material is stockpiled directly east of processing plant on the ROM pad and south of Pit A.
Pipelines	• A number of internal pipelines are used for the transportation of water, gas, diesel, air, reagents, process plant solution, sewage and tailings. • The main external pipeline is for water supply from NamWater. This pipeline is from the Omdel aquifer. It has a number of pump stations along route. LHU has authorisation to purchase 1.5 million m^3 per year from this source but currently only uses 1 million m^3 per year. LHU intends maximising consumption in 2010. • A shorter pipeline supplies water from the boreholes in the Swakop River. LHU has authorisation to receive 0.5 million m^3 per year from this source but currently only uses 50 to 70 000m^3 per year. LHU intends maximising consumption in 2010.
Power lines, substation and diesel generator	• Electricity is supplied from the NamPower Kuiseb substation close to Walvis Bay. This powerline is approximately 50 km in length and supplies approximately 16.6 MVA. • A diesel generator facility, with an approved capacity of 30 MVA, is used to augment NamPower. • There is an on-site substation and internal power lines.
Processing Plant	• The processing plant is located towards the middle of the ML. Key process components are described in Table 4-2.
Sewage Plant	• Two bio-treatment sewerage plants (trickling filter plant) are located directly west of the main office buildings. This combined facility has a capacity of 50m^3/day.
Tailings Storage Facilities (TSFs)	• The current temporary TSF is strategically located above part of the ore body to the east of the office buildings and processing plant. Once this facility is replaced with the approved permanent facility to the west of the processing plant it will be

Infrastructure	Description
	re-mined and processed. The permanent TSF will primarily be placed in mined out pits as backfill material, but a portion of the tailings will remain above ground. • Supernatant water is pumped back to the processing pond via a pipeline, to be recycled back into the process plant. Flood water is diverted around the facility and flood protection measures have been implemented in regard to the facility embankments and tailings delivery pipeline.
Topsoil stockpiles	• There are four topsoil stockpiles. These are located on the western and eastern sides of the processing plant.
Waste rock dumps (WRDs)	• There are two WRDs located to the north and east of mining Pit A and additional provision has been made adjacent to the permanent TSF. Over the mine life the number of WRDs within the ML will increase as required.
Waste - Radioactive waste disposal facility	• Disposal sites for radioactive contaminated material/waste have been established within the various waste rock dumps. This radioactive contaminated waste includes inter alia: old personal protective equipment, drums, pipes, etc.
Waste - General and non-radioactive hazardous waste handling facilities	• Hazardous waste (non radioactive) includes inter alia: fuels, chemicals, lubricating oils, hydraulic and brake fluid, paints, solvents, acids, detergents, resins, brine, solids from sewerage and sludge. • General waste includes industrial and domestic non-hazardous waste. • Facilities are provided for sorting and temporary storage prior to removal and disposal • Final disposal of these waste types is by contractors at licensed facilities in Walvis Bay and Swakopmund
Water storage facilities	• The lined raw water “turkey” dams store water that is pumped from the Swakop River borehole and from the NamWater pipeline. • NamWater is stored in three reservoirs to feed the process, in an emergency tank and in a number of potable water tanks • The process dam is a lined dam and receives water from the TSF return circuit, the open pits, the treated sewage water circuit, laboratory, wash bays, plant run-off and the process plant circuit. • As mining advances, one or more of the mined out pits will be used to contain storm water. Pit A is currently used for this purpose.
Water treatment	• A modular reverse osmosis plant is used to remove excess salts and other parameters from the incoming potable NamWater and potable Swakop River water. This is done to prevent blockages in the more sensitive processing plant components even though the incoming water is potable. The brine water from the reverse osmosis plant is used in other parts of the water circuit.

4.2. PROCESS FLOW – MAIN PROCESS COMPONENTS

A process flow diagram of the main process components activities is presented in Figure 4-2. Each step in the flow diagram is described in Table 4-2.

FIGURE 4-1: CURRENT INFRASTRUCTURE LAYOUT

FIGURE 4-2: PROCESS FLOW DIAGRAM SHOWING MAIN PROCESS COMPONENTS

TABLE 4-2: MAIN COMPONENTS OF THE EXISTING PROCESS FLOW

Stage	Description
Open pit mining	• Areas to be mined are stripped of topsoil and stockpiled and vegetation where possible re-located and re-planted. • Drilling and blasting is required to fragment the rock sufficiently so that excavation of the waste rock can be removed and the ore material stockpiled for processing. • Ore grade material is stockpiled on the run of mine (ROM) pad by haul trucks.
Crushing and scrubbing	• Ore grade material on the ROM is fed through a vibrating grizzly feeder and crushed in a crusher. • Crushed material is conveyed to the two scrubbers which serve two purposes. Firstly, the scrubber moisture breaks down the calcrete that holds the agglomerates together and secondly, the scrubbers remove the uranium bearing coating from the quartz pebbles.
Cyclones and screening	• Screened undersize from the scrubbers is pumped to the cyclones. Screened oversize is discharged to additional crushing circuits. • Cyclones are used to further separate the material. Cyclone overflows go to the pre-leach thickener after screening at 300-500 microns whilst cyclone underflow undergoes a three stage screening process to recover all 300-500 micron material that also goes to the pre-leach thickener. All material bigger than 500 microns is discharged via conveyor onto the low grade (barren) stockpiles.
Pre leach thickeners	• The 300-500 micron slurry material is pumped to two pre-leach thickeners where it is thickened to an underflow density up to 40% solids by mass with the assistance of flocculent. Thickener overflow is recycled back to the scrubbing process.
Leaching	• The thickener underflows are pumped to separate conditioning tanks where sodium carbonate and sodium bicarbonate are added. The slurry is then pumped through a first set of spiral heat exchangers where it is pre-heated by hot slurry leaving the leach circuit. It is then further heated through a second set of heat exchangers by hot water that elevates the temperature of the slurry to more than 75°C. The slurry is then discharged into either the original leach circuit comprising cascading concrete leach tanks or to the new circuit comprising two larger concrete tanks. All leach tanks are fitted with agitators to ensure optimal slurry mixing. The pH is continuously monitored and sodium carbonate and sodium bicarbonate are added as required to maintain the target of +/-pH 10. After 32 hours the leachate exits the leach tanks and is pumped through the heat exchangers to pre-heat the fresh leach feed slurry.
Counter current decantation	• The counter current decantation (CCD) circuit comprises three high density thickeners and six high rate thickeners (fed as two parallel rows of three) operating in series to make up a single Counter Current Wash circuit. Flocculent is dosed to each thickener to assist with the settling of solids. • In the final CCD stage, underflow is transferred to the tailings sump before being pumped to the TSF. Each CCD unit allows for extensive internal dilution to take place as solids contents of 3% and less are required to achieve acceptable settling rates and compaction. • Clarifier overflows are collected in pregnant solution transfer sumps and pumped to the existing pregnant solution holding tank.
Ion exchange	• The continuous fixed bed ion exchange system recovers uranium from the CCD pregnant solution. Twenty four extraction columns are used to adsorb the uranium from solution onto a weak base resin. Once the resin is fully loaded, it is eluted with sodium bi-carbonate to strip the resin of uranium into a high grade pregnant solution. Thereafter the columns are put back into an adsorption stage and the process repeats itself.
Precipitation, thickening and centrifuging	• The pregnant solution from the ion exchange/elution circuit (eluate) flows to a uranium precipitation holding tank where the pH of the solution is increased to +/-12.0 through the addition of sodium hydroxide (NaOH). This precipitates the uranium as sodium diuranate (SDU) which is collected in a thickener to increase the underflow density. • It is then pumped to a continuous wash tank to remove high levels of NaOH and then pumped to a batch precipitation tank where it is re-dissolved in sulphuric acid (H_2SO_4) at a pH of 3.6. Once all SDU is dissolved, hydrogen peroxide (H_2O_2) is added at a

Stage	Description
	controlled rate, together with NaOH (to maintain the correct pH) which causes the uranium to precipitate as UO4. The residence time for this stage is approximately 10-30 minutes. • The batch tank underflow (UO_4) is pumped firstly to a product thickener and then to a dewatering centrifuge, with dewatered uranium solids discharging into the uranium dryer feed hopper. Centrate from the centrifuge is recycled to the product thickener to recover any misplaced solids.
Product drying and drumming	• From the drier feed hopper the solids are fed to one or two oil heated dryers using an enclosed screw feeder. Drying takes place at 180°C for 1 hour to drive off free and crystalline water. The dry powder (final uranium oxide product) is then packaged in drums, weighed and sealed in preparation for transportation.

5. MOTIVATION FOR THE PROJECT AND ALTERNATIVES CONSIDERED

5.1. PROJECT MOTIVATION (NEED AND DESIRABILITY)

The motivation for the project is economic in nature. LHU has identified an opportunity to increase its supply in line with a growing global demand for uranium that will be used in power generation. The project will benefit society and the surrounding communities both directly and indirectly. Direct economic benefits will be derived from wages, taxes and profits. Indirect economic benefits will be derived from the procurement of goods and services and the increased spending power of additional employees. The challenge facing LHU is to contribute these benefits while at the same time preventing and/or mitigating potential negative social and environmental impacts as discussed in detail in Section 7.

5.2. PROJECT ALTERNATIVES

5.2.1. ALTERNATIVE SURFACE INFRASTRUCTURE LAYOUT OPTIONS

The consideration of infrastructure layout alternatives took place in 2 phases within the spatial constraint of the ML area.

In phase 1, two general areas were initially considered by the project team for the new infrastructure components. These general areas are to the east and to the west of the current activities associated with the processing plant and operational pits. The general area to the west of the current activities is clearly the better alternative because:

- there is little land to the east that is not within highly sensitive biodiversity areas;
- the more sensitive receptors from a visual, noise and air pollution perspective are on the eastern side of the ML;
- the more sensitive archaeological findings are located in the east; and
- There is less space available to the east with suitable flat topography, and that which is flat is designated for open pit mining.

In phase 2, a further analysis of alternatives was considered by both the project team and the specialists for the area to the west of the processing plant. These alternatives are depicted as options A and B on Figure 5-1 and Figure 5-2. The third option (option C) is a hybrid of components of options A and B. In this regard, it must be noted, that although the conceptual permanent above ground and in-pit tailings facilities are part of the existing approved EMP (with the aboveground facility being configured as per option A in this Section), the preferential tailings facility layout and associated impact assessment has been further considered in this EIA.

FIGURE 5-1: ALTERNATIVE LAYOUT – OPTION A

FIGURE 5-2: ALTERNATIVE LAYOUT – OPTION B

In assessing the best alternative for the infrastructure layout, the following criteria were distilled out as being the criteria of consequence:

- the layout should result in the smallest disturbance footprint;
- potential pollution sources should not be located on geological fault lines;
- sensitive biodiversity areas should be avoided;
- potential visual impacts should be limited;
- the carbon footprint of the expansion should be limited by keeping the infrastructure as close as possible to the centroid of activities which is the existing processing plant.

The site selection matrix is provided in Table 5-1. The criteria considered for each option are given a score of one to three, one being the most preferable, and three being least preferable. The site with the lowest score, taking all of the criteria into account, was considered the most preferable. On the basis of these criteria, the preferred layout is neither option A nor B, but the hybrid called option C (see Figure 6-1) that takes the best components of options A and B.

TABLE 5-1: SITE SELECTION MATRIX

Criteria	Option A	Option B	Option C	Discussion
Impacts on sensitive biodiversity areas	3	2	1	The most sensitive biodiversity area in the vicinity of the three options are the Reid wash/tributary and the Tumas wash/tributary. This is because of the vertebrate population that uses the related habitat. In option A the tailings facility will destroy the Reid wash habitat. In options B and C, the tailings facility avoids this area. In option B, the tailings facility, heap leach pad and other infrastructure encroaches on the Tumas wash/tributary, but this is avoided in options A and C.
Groundwater impacts	3	1	1	There is a geological fault associated with the Reid Wash tributary. Of the three options, the tailings facility in option A is situated immediately above this fault. In the other two options this fault is avoided.
Surface water impacts	3	3	1	Of the three options, the tailings facility in option A is situated in the Reid wash/tributary and the tailings facility, heap leach pad and other infrastructure in option B encroaches on the Tumas wash/tributary. This will impact on surface flow after rainfall events. The infrastructure in the option C layout avoids both the Tumas and Reid wash/tributaries such that surface water flow will be unimpeded.
Air quality impacts	2	3	1	The difference in rating relates to the surface area of the above ground tailings facility. It is assumed that the greater the exposed area of tailings, the greater the potential source for windblown contamination. This will be greatest for option B and least for option C.
Noise impacts	1	1	1	No relative difference has been identified.
Archaeology impacts	1	1	1	No relative difference has been identified.
Visual impacts	1	2	1	Options A and C are contained close to and shielded

Criteria	Option A	Option B	Option C	Discussion
				by the Schieferberg. Option B extends further to the west and is therefore more exposed to views from the west. This is particularly relevant to the tailings facility that will remain after mine closure.
Carbon footprint and energy use	1	2	1	The placements of the satellite workshop, plant and heap leach pad are the same for options A and C. In option B this infrastructure is located further away from the plant to cater for the split tailings facility. The further from the plant, the greater the use of energy for transport and pumping, and the greater the carbon footprint.
Physical footprint (relates to disturbance of land including soil and biodiversity)	2	3	1	The physical disturbance footprint is the smallest for option C and the largest for option B.
Total scores	17	18	9	Option C is the preferred option.

5.2.2. ALTERNATIVE WATER SUPPLY OPTIONS

The alternatives that were considered for the required increase in water supply for the proposed expansion include:

- supply from the proposed desalinisation plant that is being constructed at Wlotzkasbaken; and
- the remainder of the current approved quota that LHU is authorised to abstract from boreholes in the Swakop River.

Given that the option of receiving water from the desalinisation plant is not currently available to LHU, the only realistic option is to abstract the remainder of the Swakop River borehole abstraction quota.

5.2.3. ALTERNATIVE POWER SUPPLY OPTIONS FOR THE SWAKOP RIVER BOREHOLES

Power is required to abstract and pump water from two additional boreholes in the Swakop River. The options considered include:

- solar power units;
- additional diesel generators; and
- electrical power via a power line.

The alternative selection matrix is included in Table 5-2. As per the site selection matrix (included above), the option with the lowest score is the preferred option. In this regard, all three options have a similar score.

TABLE 5-2: BOREHOLE ALTERNATIVE POWER SUPPLY SELECTION MATRIX

Criteria	Solar	Diesel	Electrical	Discussion
Physical disturbance of land	2	1	3	Erection of the power line over a 15km route requires the disturbance of land, soils and

Criteria	Solar	Diesel	Electrical	Discussion
causing impacts on soils and biodiversity				vegetation through vehicle movement and placement of poles. This disturbance is greater than the footprint required for the diesel generators and some of the habitats through which the power line will pass are highly sensitive. Even though the generators will disturb less physical area, the generator tanks have the potential to leak small amounts of diesel into the Swakop River bed soils which can also have negative impacts on biodiversity. The physical disturbance associated with the 1200 solar panels is significant (between 600 and 1000m^2) and the building for the batteries has a footprint of approximately 200m^2.
Ground and surface water pollution	1	2	1	The only pollution potential is from diesel spills.
Localised air quality impacts	1	2	1	The only pollution potential is from generator fumes.
Noise impacts	1	3	1	The only pollution potential is from the noise of the generators
Archaeology impacts	1	1	1	All three options can be implemented in a manner that archaeological sites are avoided.
Visual impacts	2	1	2	The potential visual impact of consequence is associated with the power line and the field of solar panels. This is of particular relevance in the vicinity of the battlefield site near the Swakop River. Parts of the power line can be placed below surface to reduce this visual impact.
Feasibility (capital and maintenance costs)	3	1	2	In terms of capital cost alone the solar power will cost approximately 20 million Namibian dollars, the additional diesel generators will cost approximately 300 000 Namibian dollars, and the power line will cost approximately 2 million Namibian dollars. Long term ongoing maintenance and input costs are insignificant in comparison to the capital amounts.
Totals	11	11	11	All three options are similar

5.2.4. THE "NO PROJECT" OPTION

The assessment of this option requires a comparison between the alternative of proceeding with the expansion project with that of not proceeding with the expansion project. Proceeding with the project attracts potential economic benefits and potential negative environmental and social impacts. Not proceeding with the project leaves the status quo.

In short, the most significant potential negative environmental and social impacts associated with LHU are associated with the existing approved infrastructure and activities and not with the proposed expansion. Given this, the added potential economic benefits of the expansion are not considered to be offset by potential negative environmental and social impacts of significance.

6. PROPOSED EXPANSION PROJECT DESCRIPTION

A description of the proposed project is provided below. The project description should be read with reference to Figure 6-1, Figure 6-2, Figure 6-3 and Figure 6-4.

6.1. CONSTRUCTION PHASE

A summary of the key construction activities (per project component) is provided in Table 6-2. Other construction related issues are discussed below.

6.1.1. SITE FACILITIES FOR CONSTRUCTION

A number of temporary contractor's working areas will be established on site during construction. The locations of the temporary working areas are within the current plant and the proposed mine workshop as shown in Figure 6-1. These areas will be fenced and will incorporate some or all of the facilities described below:

- a workshop/maintenance area for servicing and maintaining equipment and vehicles;
- a lay-down area;
- a temporary waste collection and storage area;
- a wash bay for washing equipment and vehicles;
- a store for storing and handling fuel, lubricants, solvents, paints and construction substances;
- a parking area for cars and equipment;
- mobile site offices;
- a canteen;
- portable ablution facilities;
- a clean water reservoir;
- change houses; and
- temporary power generating infrastructure.

6.1.2. TRANSPORT

During the construction of the project there will be an increase in the number of workers travelling to and from site and there will be an increase in heavy vehicles supplying input materials. The estimated average increase in vehicle numbers for the 12 month construction period is as follows:

- an additional 4 buses taking workers to site on Monday morning;
- an additional 4 buses taking workers to Swakopmund and/or Walvis bay on Saturday afternoon;
- an additional 6 trucks a week for delivering construction related supplies and for taking waste from site.

6.1.3. EMPLOYMENT AND HOUSING

During the construction phase, between 150 and 300 temporary jobs will be created. Most of the workers will be housed on-site in a contractor's camp.

TABLE 6-1: CONTRACTOR'S CAMP

Item	Description
Duration	The camp will be a temporary facility that is required for approximately 12 months.
Capacity	The camp will be designed to house up to 300 occupants during peak construction periods.
Occupants	Only construction workers and camp facility service personnel will be permitted to stay in the camp.
Visitors	No visitors will be allowed.
Rooms	The rooms will be a combination of tents built on wooden floors, prefabricated rooms, and/or metal containers. Rooms will house up to 4 people at a time.
Recreation amenities	The camp will be equipped with amenities for the enjoyment of the occupants. These typically include: DSTV, pool tables, table tennis, gym, basketball court, canteen, and pub.
Ablution facilities	Portable toilets and showers will be provided.
Transport	The construction work cycle is 6 days on duty and 1 day off duty. Therefore, camp occupants will be transported to and from site by bus from Walvis Bay and/or Swakopmund on a weekly basis.
Potable water	Potable water for drinking, cooking and ablutions will be sourced from the existing Langer Heinrich supply and/or be trucked in using water tankers.
Power supply	Power will be sourced from generators. Approximately 600 KW is required.
Sewage	Sewage from the portable toilets will be treated in a self contained unit. Treated water will be reused in the LHU process water/dust suppression system. The remaining solids will be extracted by the Walvis Bay municipality for final disposal at the Walvis Bay sewage treatment plant.
General waste	Designated waste skips will be provided and waste will be managed as part of the current mine waste management system. All general waste is disposed at the Walvis Bay disposal site.
Health, safety and environment	All camp occupants will receive induction on arrival.
Security	The camp will be fenced and will have one access gate with 24 hour security.

6.1.4. WATER SUPPLY FOR CONSTRUCTION ACTIVITIES

Water supply for construction activities will be obtained from LHU's existing water supply (combination of NamWater and water from the Swakop River boreholes).

6.1.5. POWER SUPPLY FOR CONSTRUCTION ACTIVITIES

Power supply for construction activities will be from small mobile generators.

6.1.6. SANITATION FOR CONSTRUCTION

Portable toilets will be available on the various construction sites.

6.1.7. WASTE MANAGEMENT FOR CONSTRUCTION

Construction waste management will be in accordance with current operational procedures.

6.1.8. TIME TABLE

Construction activities will commence on project approval. The target is the last quarter of 2009.

FIGURE 6-1: CUMULATIVE INFRASTRUCTURE LAYOUT – ZOOMED OUT

FIGURE 6-2: CUMULATIVE INFRASTRUCTURE LAYOUT– ZOOMED IN

FIGURE 6-3: PROPOSED UPGRADES TO EXISTING PLANT

FIGURE 6-4: PROPOSED HEAP LEACH PAD LAYOUT

TABLE 6-2: SUMMARY OF CONSTRUCTION ACTIVITIES

Activity		Satellite Workshop	Heap Leach Pad	Tailings Thickener	Process Plant					West of permanent TSF	Electricity line from Swakop River
					Leach tanks & CCD	HFO/diesel powered steam boilers and related storage facilities	Additional heat exchangers	Reagent storage and mixing facilities	Addition crushing and scrubbing facilities		
A1	Earthworks: Drilling and blasting activities	X		X	X				X	X	
A2	Earthworks: Cleaning and grubbing and bulldozing activities	X	X	X	X	X	X	X	X	X	X
A3	Earthworks: Soil excavation	X	X	X	X	X	X	X	X	X	X
A4	Earthwork: Stockpiling of topsoil and other material	X	X	X						X	X
A5	Disposal of contaminated soil				X	X	X	X	X		
A6	Backfill of material (specific grade) from borrow pits	X	X	X	X	X	X	X	X	X	X
A7	Opening and management of borrow pits	X	X	X	X	X	X	X	X	X	X
A8	Construction and use of new access roads – clearing of areas	X	X	X	X					X	X
A9	Civil works: Foundation excavations	X	X	X	X	X	X	X	X	X	X
A10	Building activities	X	X	X	X	X	X	X	X	X	
A11	Storage and handling of material: Sand, rock, cement, chemical additives in cements (leach tanks only)	X	X	X	X	X	X	X	X	X	X

Activity		Satellite Workshop	Heap Leach Pad	Tailings Thickener	Process Plant					West of permanent TSF	Electricity line from Swakop River
					Leach tanks & CCD	HFO/diesel powered steam boilers and related storage facilities	Additional heat exchangers	Reagent storage and mixing facilities	Addition crushing and scrubbing facilities		
A12	Water utilization	X	X	X	X	X	X	X	X	X	X
A13	Mixing of concrete (batch plant) and concrete work (casting)	X	X	X	X	X	X	X	X	X	X
A14	Operation and movement of construction vehicles and machinery	X	X	X	X	X	X	X	X	X	X
A15	Refuelling of equipment (at existing facility at the process plant)	X	X	X	X	X	X	X	X	X	X
A16	Use of cranes	X	X	X	X	X	X	X	X	X	X
A17	Erection and destruction of scaffolding	X	X	X	X	X	X	X	X	X	
A18	Building of shutters (re-usable shutters)	X	X	X	X	X	X	X	X	X	
A19	Installing re-enforcement Steel	X	X	X	X	X	X	X	X	X	
A20	Handling, storage and disposal of hazardous waste • Blasting media packing material • Empty paint containers • Cements bags • Chemical additives (for cement) containers • Contaminated PPE and other (with oil,	X	X	X	X	X	X	X	X	X	X

Activity		Satellite Workshop	Heap Leach Pad	Tailings Thickener	Process Plant					West of permanent TSF	Electricity line from Swakop River
					Leach tanks & CCD	HFO/diesel powered steam boilers and related storage facilities	Additional heat exchangers	Reagent storage and mixing facilities	Addition crushing and scrubbing facilities		
	uranium, etc). • Redundant concrete										
A21	Handling, storage and disposal of non-hazardous waste • Steel off-cuts • Domestic waste • Wood off-cuts • Grinding wheels • Other construction waste	X	X	X	X	X	X	X	X	X	X
A22	Transportation of hazardous material	X	X	X	X	X	X	X	X	X	X
A23	Transportation of non-hazardous material	X	X	X	X	X	X	X	X	X	X
A24	Handling and storage of Hazardous material • Blasting media • Paints • Gas (welding) • Cement • Chemical additives for cement for leach tanks only)	X	X	X	X	X	X	X	X	X	X
A25	Install pipelines for water and process solutions	X	X	X	X	X	X	X	X	X	X

Activity		Satellite Workshop	Heap Leach Pad	Tailings Thickener	Process Plant					West of permanent TSF	Electricity line from Swakop River
					Leach tanks & CCD	HFO/diesel powered steam boilers and related storage facilities	Additional heat exchangers	Reagent storage and mixing facilities	Addition crushing and scrubbing facilities		
	(Above ground)										
A26	Install of electricity lines	X	X	X						X	X
A27	Use of electricity generators	X	X	X						X	X
A28	Install transformers	X	X	X						X	X
A29	Install parking bay for trucks	X		X						X	X
A30	Manage construction site	X	X	X	X	X	X	X	X	X	X
A31	Painting, grind and welding	X	X	X	X	X	X	X	X	X	X
A32	Provision and operation of water washing and toilet facilities	X	X	X						X	X
A33	Slope stabilization and erosion control	X	X	X	X				X	X	
A34	Appointment of contractors, labourers, etc. • Civil contractor • Structural contractor • Electrical contractor	X	X	X	X	X	X	X	X	X	X

6.2. OPERATION PHASE

6.2.1. INCREASED RATE OF MINING

More detailed exploration work has confirmed that the uranium resource within the ML is greater than initially anticipated. An increase in the rate of mining will enable an increase in the uranium production rate provided that the various components of the project are approved.

6.2.2. SATELLITE MINE WORKSHOP

As mining advances to the west, a satellite mine workshop is required for refuelling, servicing and storage of mine equipment and vehicles. The related infrastructure components are:

- workshop buildings;
- offices;
- store room;
- diesel storage facility;
- wash bay with effluent sump and oil trap;
- self contained ablution facility ;
- potable water supply pipeline and storage tanks;
- internal power supply; and
- an internal access road.

6.2.3. ADDITIONAL CRUSHING AND SCRUBBING CAPACITY

Additional crushing and scrubbing capacity will be required at the existing plant and at the satellite location to the west of the permanent TSF. The related infrastructure for the satellite plant is as follows (apart from the proposed additional crushing and scrubbing facilities, most of this related infrastructure is already in place at the existing plant):

- offices and store room;
- stockpiles;
- conveyors;
- crushers;
- scrubbers;
- pumps;
- pipelines for slurry, process and potable water;
- water storage tanks;
- self contained ablution facility;
- internal power supply; and
- an internal access road.

6.2.4. HEAP LEACH PAD

The heap leach pad will be constructed to recover uranium from low grade ore and barren material that is currently stockpiled on-site. The life of the heap leach operation is approximately 18 years. If the heap leach operation does not eventuate, these materials will either be left as long term waste stockpiles or be processed through the plant and ultimately be disposed as tailings.

Design Criteria

The following are the current estimates for key design data for the heap leach operation (note all figures are indicative only):

ITEM	UNITS	VALUE
Treatment Rate	Tonnes per annum	3,500,000
Feed Material Size	mm	100% -500mm
Crushed Product Size	mm	-38 + 10
Fines Production (-10mm)	%	25
Head Grade	ppm U_3O_8	+/-200
Average Leach Period	Days	120
Uranium Recovery	%	70-80
Water Consumption (per tonne treated)	m^3	0.25
Water Consumption	m^3/annum	875,000
Power Installed	kW	2,000,000
Power Consumption	MWhr/a	8,000

Ore Preparation

A multi-stage crushing and screening facility will be installed to reduce the low grade ore to approximately -38mm + 10mm in size (actual sizes still to be confirmed). This material will then be transported by a series of conveyors and stacker conveyors to the heap leach pads for uranium recovery. All -10mm material will be slurried and pumped to the existing scrubbing facilities where uranium will be recovered through the conventional leach plant.

Leach Pads

Six leach pads (Figure 6-4) will be constructed operating in a carousel configuration (one being loaded with new ore, one being used to wash the ore, three being leached and one being emptied of leached ore). Each pad will hold approximately 300,000 tonnes of ore with basic dimensions of 150m x 150m each and 9m height. The pads will have multiple linings with leak detection and collection facilities, and the linings will be repaired/replaced as required. After leaching, the waste material will either be reclaimed and disposed as part of the permanent TSFs (above ground and/or in-pit) or it will placed on aboveground stockpile(s) after being washed to remove excess contaminants.

Leach solution will be sodium carbonate/bicarbonate dosed onto the pads by a network of temporary piping and drippers. Leach solution will permeate through the heap and gravitate to a collection sump where it will either be recycled back to the heap or pumped to a new uranium recovery plant.

Solution Ponds

Six solution ponds (one per pad) will be installed to provide buffer storage for the leach solutions and barren solution (post uranium recovery). Each pond will have multiple liners and be equipped with leak detection and collection facilities. Pumps will deliver the solutions to the various leach pads or processing plant.

Recovery Plant

The uranium bearing (pregnant) solution will be pumped from one of the solution ponds to the current ion exchange columns at the existing plant where the uranium will be adsorbed onto the resin. The barren/stripped solution will then be recycled back to the heap leach operation.

Loaded resin in the ion exchange columns will be transferred periodically to separate vessels where a concentrated sodium bicarbonate solution will be used to strip (elute) the uranium from the resin. This solution, rich in uranium, will be pumped to the existing precipitation plant for production of the final uranium.

Additional reagent mixing facilities will be installed at the new plant to provide sodium carbonate and bicarbonate solutions for the leaching and elution processes.

Related heap leach infrastructure

The related infrastructure components are:

- self contained ablution facility;
- crushers;
- conveyors;
- stockpiles;
- reagent storage and dosing facilities;
- pumps and pipelines for supplying process water, potable water and for transporting the leachate to the process plant;
- storage tanks;
- internal power supply; and
- an internal access road.

6.2.5. PROCESSING PLANT

The existing process plant requires expansion. The related components are provided in Table 6-3 and shown on Figure 6-3.

TABLE 6-3: PROCESS PLANT EXPANSION COMPONENTS

Processing activity	**Description**
Crushing and scrubbing	Additional crushing and scrubbing facilities as discussed in section 6.2.3
Leaching	Additional leach tanks
	Heavy fuel oil (HFO)/diesel powered steam boilers and related storage facilities
	Additional heat exchangers
Counter current decantation (CCD) circuit	2 new CCD thickeners
Ion exchange plant	New adsorption and elution columns
Reagent storage	Expansion of reagent storage and mixing facilities

6.2.6. TAILINGS THICKENER PLANT

It is proposed that a thickener plant will be located adjacent to the permanent TSF. The purpose of the thickener plant is to reduce the moisture content of the tailings stream prior to deposition in order to maximise the reuse of water in the processing plant and reduce the amount of water on the TSF, which will therefore reduce the leaching/seepage potential from the TSF.

Slurry from the process plant containing approximately 40% solids will be pumped from the main plant to a surge tank located close to the new tailings storage dam. From this tank the slurry will be pumped to a high density deep cone thickener where flocculent will be added to assist with solids settlement. Thickener underflow slurry is pumped onto the new tailings dam. The thickener overflow (water) will be collected in a surge tank and pumped back to the main process plant together with any water decanted from the tailings dam.

The related components include:

- thickener
- tanks and pumps
- pipelines
- flocculent mixing and dosing facilities
- bunded area (approximately 30m x 30m)

6.2.7. TRANSPORT

As a result of the project there will be an increase in the number of workers travelling to and from site each day for operational purposes, there will be an increase in heavy vehicles supplying input materials to the mine and collecting waste during operations, and there will be an increase in the amount of trucks required to transport product from site. The estimated average increase in vehicle numbers is as follows:

- an additional 2 buses a day required for transporting workers (Monday to Friday);
- an additional 4 trucks a day for delivering supplies and collecting waste material; and
- an additional 3 trucks a quarter for transporting product.

The permanent TSF, planned mining and proposed additional infrastructure will impede the current access road to site. Once the wall of the permanent above ground tailings facility is constructed, the new road will cross the wall. In the interim, the road will be diverted between the mining pits to the north.

6.2.8. POWER SUPPLY

Power is currently supplied by a combination of NamPower and on-site generators. The existing approved power sources are sufficient to provide the required 48MVA for the current operations and the proposed project. If LHU determines that additional power is required from NamPower in place of using all of the on-site generation capacity, this may require an upgrade to the current power line or a new power line. Any related EIA process will be commissioned by NamPower and is not considered in this EIA.

Any additional internal reticulation of power between the existing plant, the permanent TSF and the proposed infrastructure to the west of the permanent TSF will generally follow the corridor of the existing NamPower line. If diesel generators are used for this purpose, these will be placed the adjacent to the abstraction boreholes (as is the case for the existing abstraction borehole). If a power line is used to supply power to the additional Swakop River abstraction boreholes, this line will follow the existing pipeline and associated gravel track. Wooden poles (9m in height) will be erected approximately every 100m in 1.5m deep holes of approximately 250mm diameter. These holes are drilled by truck mounted rig that will have to drive along the existing gravel road.

6.2.9. WATER SUPPLY

Water supply is the critical factor in determining the expansion production level. LHU has developed a daily operational water balance that takes account of the main inputs and outputs including evaporation losses. Approximately 2 million m^3 of additional make up water per annum (over and above current allowances) would be required to enable the expansion project to reach the higher production level of 10 million pounds of uranium oxide per annum. In the normal course, recycling dirty/process water and captured storm water is a priority, therefore, as discussed in Section 5.2.2, the only immediate additional supply option is for LHU to fully utilise the existing water allocation from boreholes in the Swakop River. This is sufficient water to achieve a production level of approximately 5.2 million pounds of uranium oxide per annum.

The additional infrastructure required for additional abstraction in the Swakop River is as follows:

- converting two of the existing boreholes (WW41188 and WW41190) to production boreholes by inserting abstraction pumps;
- linking these boreholes to the current abstraction borehole (WW41183) by means of a 9km long, 160mm diameter pipeline that will be buried in the Swakop River outside of the main channel;
- erecting a holding reservoir at the current abstraction borehole (WW41183);
- additional pump for transferring water from the Swakop River to the receiving dam(s) in the ML; and
- providing additional power by means of a power line and/or diesel generators.

6.2.10. WATER MANAGEMENT

Water management facilities for the control of storm water and for pollution prevention will be implemented to prevent flood damage, and to keep clean run-off water separate from dirty process water. In this regard, all new infrastructure will be designed with:

- upstream clean run off diversions; and
- dirty water collection and recycling facilities for handling both process water and any rainfall that falls within an area that could be a contamination source.

Any additional internal pipelines (for clean and/or dirty water) between the existing plant, the permanent TSF and the proposed infrastructure to the west of the permanent TSF will generally follow the corridor of the existing NamWater line.

6.2.11. WASTE MANAGEMENT

The mine's existing waste management procedure and facilities (see Section 4) will be used for any additional waste quantities that are produced by the proposed project.

6.2.12. EMPLOYMENT AND HOUSING

Approximately 90 permanent new jobs (employees and long-term contractors) will be created as part of the project during the operational phase. Permanent employees and long-term contractors will be housed off site in Swakopmund or Walvis Bay.

6.3. DECOMMISSIONING AND CLOSURE PHASE

The planning stage for decommissioning and closure has commenced and in broad terms the main objective will be to remove as much infrastructure as possible and rehabilitate what remains to resemble the pre project land state as closely as possible. At this stage, the proposed post closure land use will be a combination of conservation and wilderness.

As part of this closure planning process, LHU will develop concepts and designs that will be circulated for stakeholder comment. This planning process will be ongoing throughout the life of the mine.

Given the above, a conceptual assessment of decommissioning and closure activities and infrastructure has been provided in Section 7.

6.4. TIMETABLE

Subject to authorisation and the construction programme (approximately 12 months), operation of the various project components will begin in 2010. The estimated life of mine, taking the project into account, is approximately 25 years.

7. ENVIRONMENTAL IMPACT ASSESSMENT

Potential environmental impacts were identified by Metago in consultation with IAPs, regulatory authorities, specialist consultants and LHU. The impacts are discussed under issue headings in this section. All identified impacts are considered in a cumulative manner such that the impacts of the current activities and those potentially associated with the project are discussed and assessed together. In this regard, impacts of the various (surrounding/neighbouring) mining and exploration activities in the region have not, as a general rule, been cumulatively assessed in the EIA. It is understood that this regional cumulative assessment is the role of the strategic environmental assessment that was commissioned for the mining industry in the Erongo region in the 2009.

The discussion and impact assessment for each sub-section covers the construction, operational, decommissioning and closure phases where relevant. This is indicated in the table at the beginning of each sub-section. Included in the table is a list of project activities/infrastructure that could cause the potential impact per mine phase. The activities/infrastructure link to the description of both the current and proposed project (Sections 4 and 6 of the EIA report).

Management measures to address the identified impacts are discussed in this section and included in the EMP report that is attached in Appendix Q. These are a combination of existing LHU measures and proposed LHU measures. In most cases (unless otherwise stated), these management measures have been taken into account in the assessment of the significance of the managed/mitigated impacts only and the unmanaged scenario does not take account of either the current or proposed management on site. This unmanaged scenario is conservative because environmental management is in place at LHU, but for the purpose of the EIA it is considered relevant because all of the proposed activities and a significant number of the approved activities have yet to commence.

An example of how this chapter is structured is given in the text box on the following page. Both the criteria used to assess the impacts and the method of determining the significance of the impacts is outlined in Table 7-1. This method complies with the method provided in the draft Namibian EIA regulations (April 2009). Part A provides the approach for determining impact consequence (combining severity, spatial scale and duration) and impact significance (the overall rating of the impact). Impact consequence and significance are determined from Part B and C. The interpretation of the impact significance is given in Part D. Both mitigated and unmitigated scenarios are considered for each impact.

EXAMPLE SHOWING HOW THIS CHAPTER HAS BEEN STRUCTURED

5.2 TOPOGRAPHY

Environmental component heading

5.2.1 ISSUE: HAZARDOUS EXCAVATIONS

Issue heading

Project phase and link to activities/infrastructure

Construction	Operational	Decommissioning	Closure
			N/A*
Activity/infrastructure 1 Activity/infrastructure 2	Activity/infrastructure 1 Activity/infrastructure 2	Activity/infrastructure 1	-

** N/A – not applicable.*

Bars showing phase of operation in which impacts could occur, and link to project activities

Description of impact

Description of the issue and associated impact.

Tabulated summary of the assessed impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**M**	**L**	**M**	**M**	**M**
Managed	**L**	**L**	**L**	**L**	**L**	**L**

Conceptual description of existing and proposed LHU management measures

Description of management objectives and actions

TABLE 7-1: CRITERIA FOR ASSESSING IMPACTS

PART A: DEFINITION AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of severity, spatial extent and duration**
Criteria for ranking of the SEVERITY/NATURE of environmental impacts	**H**	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action. Irreplaceable loss of resources.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints. Noticeable loss of resources.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. Limited loss of resources.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	**L**	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	**L**	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national

PART B: DETERMINING CONSEQUENCE					
SEVERITY = L					
DURATION	Long term	**H**	**Medium**	**Medium**	**Medium**
	Medium term	**M**	**Low**	**Low**	**Medium**
	Short term	**L**	**Low**	**Low**	**Medium**
SEVERITY = M					
DURATION	Long term	**H**	**Medium**	**High**	**High**
	Medium term	**M**	**Medium**	**Medium**	**High**
	Short term	**L**	**Low**	**Medium**	**Medium**
SEVERITY = H					
DURATION	Long term	**H**	**High**	**High**	**High**
	Medium term	**M**	**Medium**	**Medium**	**High**
	Short term	**L**	**Medium**	**Medium**	**High**
			L	**M**	**H**
			Localised Within site boundary Site	Fairly widespread Beyond site boundary Local	Widespread Far beyond site boundary Regional/ national
			SPATIAL SCALE		
PART C: DETERMINING SIGNIFICANCE					
PROBABILITY (of exposure to impacts)	Definite/ Continuous	**H**	**Medium**	**Medium**	**High**
	Possible/ frequent	**M**	**Medium**	**Medium**	**High**
	Unlikely/ seldom	**L**	**Low**	**Low**	**Medium**
			L	**M**	**H**
			CONSEQUENCE		

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
High	It would influence the decision regardless of any possible mitigation.
Medium	It should have an influence on the decision unless it is mitigated.
Low	It will not have an influence on the decision.

***H = high, M= medium and L= low and + denotes a positive impact.**

7.1. TOPOGRAPHY

The topography has been changed by current activities and further changes are expected if the project is implemented. The following related issues have been identified and are discussed further in the sections highlighted in brackets:

- hazardous excavations and infrastructure and the dangers they present to animals and humans (Section 7.1.1); and
- visual impacts (Section 7.10).

7.1.1. ISSUE: HAZARDOUS EXCAVATIONS AND INFRASTRUCTURE

TABLE 7-2: HAZARDOUS EXCAVATIONS AND INFRASTRUCTURE - LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
Foundations Trenches Stockpiles Scaffolding Cranes Borrow pits	Open pits Stockpiles TSFs Heap leach pad Water dams/reservoirs Voids Trenches Buildings and equipment Surface subsidence Pipelines	Open pits Stockpiles TSFs Heap leach pad Water dams/reservoirs Voids Trenches Surface subsidence Scaffolding Cranes Piles of rubble Piles of scrap	Permanent TSF Permanent water dams Permanent stockpiles Final voids (if any) Surface subsidence

Assessment of impact

Introduction

With reference to Table 7-2, hazardous excavations and infrastructure include all structures into or off which third parties and animals can fall and be harmed. Included in this category are facilities that can fail (such as the permanent above ground TSF and the proposed heap leach pad), and the context of open pit mining, surface settlement can occur if backfilled material is inadequately compacted. Hazardous excavations and infrastructure occur in all project phases from construction through operation to decommissioning and closure. In the construction and decommissioning phases these hazardous excavations and infrastructure are temporary in nature, usually existing for a few weeks to a few months. The operational phase will present more long term hazardous excavations and infrastructure and the closure phase will present final land forms that may be considered hazardous.

Severity

In unmanaged scenario, most of the identified hazardous excavations and infrastructure present a potential risk of injury and/or death to both animals and third parties which includes contractors and drillers staying at the mine overnight. This is a potential high severity. With management, the severity reduces to medium

Duration

In the context of this assessment, death or permanent injury is considered a long term, permanent impact.

Spatial scale

For the most part, the related impacts will be located within the ML. The exception is potential drowning at the proposed reservoir at the Swakop River boreholes.

<u>Consequence</u>

In both the managed and the unmanaged scenario, the consequence of this potential impact is high.

<u>Probability</u>

In the case of third parties, in the unmanaged scenario, there is a limited possibility that the hazardous excavations and infrastructure present a risk to unaccompanied third parties during construction, operation and decommissioning because the proposed Swakop reservoir and ML are in remote areas. Even so, it is not impossible that people can access the reservoir area and hike into the eastern part of the ML.

Given the proximity of most of the infrastructure to rivers, flood damage may increase the risk of failure of mineralised facilities (TSF, heap leach pad, other stockpiles) in the unmanaged scenario.

After closure, the final landforms may present a risk to third parties depending on infrastructure stability and on access to the ML.

In the case of animals, a number of vertebrate drowning incidents have been recorded, and in all phases animals have access to most of the ML and the Swakop River and may be injured or killed.

The proposed management measures will focus on the safety and stability of the infrastructure and on limiting access to third parties and animals which reduces the probability of the impact occurring.

<u>Significance</u>

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance of this potential impact is medium because there will be a reduction in probability that the impact occurs.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**M**	**H**
Managed	**M**	**H**	**M**	**H**	**L**	**M**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

<u>Objective</u>

The objective of the management measures is to prevent physical harm to third parties and animals from potentially hazardous excavations.

Actions

During the construction, operation and decommissioning phases, barriers and/or warning signs will be used to keep people and animals away from both the ML and the hazardous excavations and infrastructure.

Information will be provided at stakeholder information meetings to educate third parties about the dangers associated with hazardous excavations and infrastructure.

Open pit backfilling operations will take the possibility of surface settlement into account. This requires compaction of backfilled material. Final replacement of topsoil onto the backfilled overburden/waste rock material will be done with the understanding that if settlement occurs thereafter, re stripping of topsoil and additional backfilling with overburden/waste rock will be required. Thereafter the topsoil will have to be replaced.

The permanent aboveground TSF, heap leach pad and other stockpiles will be designed, constructed and operated in a manner that stability is a priority, that flood protection is provided and that the risk of failure is limited to acceptable levels.

Permanent aboveground mineralised waste stockpiles will be rehabilitated and closed in a manner that they present land forms that have similar safety attributes to the natural land forms in the area. In this regard, structures will be stable, protected from flood damage, final voids will be backfilled and steep slopes will be contoured.

Emergency situations

If people or animals do fall off or into hazardous excavations or infrastructure causing injury, or if the TSF or any other facilities fail causing injury to people or animals, the LHU emergency response procedure will be followed.

7.2. SOILS AND LAND CAPABILITY

The information in this section was sourced from the soil specialist study in Appendix H (ESS, 2009).

The physical loss of soils and/or the loss of soil functionality are important issues because as an ecological driver, soil is the medium in which most vegetation grows and a significant range of vertebrates and invertebrates exist. In the context of mining, it is even more of an issue if one considers that mining is a temporary land use where-after rehabilitation is the key to re-establishing post closure land capability that will support conservation and ecotourism type land uses. Soil is a key part of rehabilitation. It is in this context that impacts on soils are assessed below.

7.2.1. ISSUE: LOSS OF SOIL RESOURCES FROM POLLUTION

TABLE 7-3: POLLUTION OF SOILS –LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning – cumulative	Closure – cumulative
General building activities Management of dirty water Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (non-mineralised) Equipment servicing Use of vehicles and equipment that may leak lubricants and fuel	Servicing equipment Management of dirty process water/effluent Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (mineralised and non-mineralised) Heap leach pad	General building activities Management of dirty water Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (mineralised and non-mineralised) Heap leach pad Equipment servicing Use of vehicles and equipment that may leak lubricants and fuel	Seepage from remaining waste stockpiles, catchment dams and TSF

Assessment of impact

Introduction

With reference to Table 7-3, there are a number of potential pollution sources in all phases that have the potential to pollute soils particularly in the unmanaged scenario. In the construction and decommissioning phases these potential pollution sources are temporary in nature, usually existing for a few weeks to a few months. Although the sources are temporary in nature, the potential related pollution can have long term effects. The operational phase will present more long term potential sources and the closure phase will present final land forms that may have the potential to contaminate soils through long term seepage and/or run-off.

Severity

In the unmanaged scenario, pollution of soils from numerous pollution incidents can result in a loss of soil functionality as an ecological driver because it can create a toxic environment for vegetation, vertebrates and invertebrates that rely on the soil, and/or it can negatively impact on the chemistry of the soils such that current growth conditions are impaired. This is a high severity. In the managed scenario, the number of pollution events should be significantly less than in the unmanaged scenario which reduces the potential severity to medium.

Duration

In the unmanaged scenario, most pollution impacts will remain until long after closure. In the managed scenario most of these potential impacts should either be avoided or be remedied within the life of the mine. Important related issues are the reaction time of the cleanup team and the chosen remediation methods, which need to be careful considered in the desert environment because it has different underlying processes in the soil when compared to wetter environments.

Spatial scale

Potential soil pollution will be restricted to the ML and the existing and proposed diesel generators at the Swakop River boreholes.

Consequence

In the unmanaged scenario, the consequence of this potential impact is high. In the managed scenario, this reduces to medium because the severity and duration of the impacts is reduced.

Probability

Without any management the probability of impacting on soils through pollution events is high. With management, the probability will be significantly reduced because emphasis will be placed on preventing pollution events and on quick and effective remediation if pollution events do occur.

Significance

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance reduces to low because with management the severity, duration and probability associated with the potential the impact all reduce.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**L**	**H**	**H**	**H**
Managed	**M**	**M**	**L**	**M**	**L**	**L**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent pollution of soils.

Actions

In the construction, operation and decommissioning phases LHU will ensure that all hazardous chemicals (new and used), dirty water, mineralised wastes and non-mineralised wastes are handled in a manner that they do not pollute soils. This will be implemented through the EMP and one or more procedure(s) covering the following:

- pollution prevention through basic infrastructure design and through education and training of workers (permanent and temporary);

- the required steps to enable fast reaction to contain and remediate pollution incidents. In this regard the remediation options include in situ treatment or disposal of contaminated soils as hazardous waste. The former is generally considered to be the preferred option because with successful in situ remediation the soil resource will be retained in the correct place. The in situ options include bioremediation at the point of pollution, or removal of soils for washing and/or bio remediation at a designated area after which the soils are replaced; and
- specifications for post rehabilitation audit criteria to ascertain whether the remediation has been successful.

As part of closure planning, the designs of any permanent and potentially polluting structures (mineralised waste facilities) will take consideration of the requirements for long term pollution prevention and confirmatory monitoring.

Emergency situations

Major spillage incidents will be handled in accordance with the LHU emergency response procedure.

7.2.2. ISSUE: LOSS OF SOIL RESOURCES FROM PHYSICAL DISTURBANCE

TABLE 7-4: PHYSICAL DISTURBANCE OF SOILS – LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning – cumulative	Closure – cumulative
Soil stripping Cleaning and grubbing Preparation of the foundations Compacting bases Opening borrow pits and trenches General building activities Slope stabilization Building roads Vehicle movement	Mining development Vehicle movement Stockpile development TSF development Exploration	Soil stripping Cleaning and grubbing Material movement General building activities Slope stabilization Vehicle movement	Erosion of final land forms

Assessment of impact

Introduction

With reference to Table 7-4, there are a number of activities/infrastructure in all phases that have the potential to disturb soils through compaction and/or erosion. In the construction and decommissioning phases these activities are temporary in nature, usually existing for a few weeks to a few months. The operational phase will present more long term activities and the closure phase will present final land forms that may be susceptible to erosion.

Severity

In the unmanaged scenario, physical soil disturbance can result in a loss of soil functionality as an ecological driver because in the case of erosion, the soils will be lost to the area of disturbance and in the case of compaction the soils functionality will firstly be compromised through a lack of rooting ability and aeration, and secondly the compacted soils are likely to erode because with less inherent functionality there will be little chance for the establishment of vegetation and other matter that naturally protects the soils from erosion. In the context of the soil horizons that have been identified by the specialist, this issue is further complicated because of the occurrence of the upper soil crust on the plains and the calcrete layer beneath the alluvial soils. Both of these features are considered to be important aspects of the ecosystem functionality. In the case of the calcrete layer, the key issue is its impermeable nature which retains moisture in the lower part of the upper soil horizon. In the case of the crust, it prevents erosion of the underlying soils and may also retain moisture in those soils. In the managed scenario, the soils can be conserved and reused, but it is not yet clear whether the calcrete and crust layers can be effectively re-established with the same or similar material. As a combination, these management measures reduce the high severity to medium.

Duration

In the unmanaged scenario the loss of soil and related functionality is long term and will continue after the life of the mine. In the managed scenario, the soil is conserved and replaced which reduces the duration of the impact.

Spatial scale

Physical disturbance of the soil will be restricted to the ML and the infrastructure/activities associated with abstracting and piping water from the Swakop River boreholes.

Consequence

In the unmanaged scenario, the consequence of this potential impact is high. In the managed scenario this reduces to medium because the severity and duration of the impacts may be reduced.

Probability

Without any management the probability of losing soil and its functionality is definite. With management, the probability will be reduced because emphasis will be placed on soil conservation and re-establishment. In this regard, there remains some uncertainty about the chances of effectively rehabilitating the calcrete and crust layers (with the same or similar material) and the role they play as ecological drivers.

Significance

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance could reduce to medium but the success of the management measures remains untested.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**L**	**H**	**H**	**H**
Managed	**M**	**M**	**L**	**M**	**M-H**	**M-H**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent the loss of soils and related functionality through physical disturbance, erosion and compaction.

Actions

In the construction, operation and decommissioning phases a soil management plan will be implemented. The key components are:

- limit the disturbance of soils to what is absolutely necessary;
- where soils have to be disturbed the soil will be stripped, stored, maintained and replaced in accordance with the specifications of the soil management plan; and
- pilot studies will be undertaken during the operation phase to determine the best method of re-creating the subsurface impermeable layer (in its natural form this is calcrete but it may be possible to recreate it with similar material) and crust layers, and restoring their role as ecological drivers.

As part of closure planning, the designs of any permanent structures (mineralised waste facilities) will take into consideration the requirements for long term erosion prevention and confirmatory monitoring.

Emergency situations

None identified.

7.3. BIODIVERSITY - NATURAL VEGETATION AND ANIMAL LIFE

The information in this section was sourced from the vegetation, invertebrate and vertebrate specialist studies in Appendix I (Yates 2009, Irish 2009, Henschel 2009).

Although three specialist studies were undertaken on vegetation, invertebrates and vertebrates, the approach to the impact assessment is to group the three categories into one interrelated biodiversity category. It must be noted that each of the specialist reports has recorded detailed and specific information on the habitats, species, threats, and related management and restoration possibilities and requirements. It is not possible to capture all of this information in this section of the EIA, which is intended to be a high level assessment. Therefore, readers must be aware of the content of the baseline description (Sections 3.6, 3.7 and 3.8), the content of the specialist reports (Appendix I) and the EMP (Appendix Q) when reading this section.

In the broadest sense, biodiversity provides value for ecosystem functionality, aesthetic, spiritual, cultural, and recreational reasons. The known ecosystem related value is listed as follows:

- soil formation and fertility maintenance;
- primary production through photosynthesis, as the supportive foundation for all life;
- provision of food and fuel;
- provision of shelter and building materials;
- regulation of water flows and water quality;
- regulation and purification of atmospheric gases;
- moderation of climate and weather;
- control of pests and diseases; and
- maintenance of genetic resources (key for medicines, crop, and livestock breeding).

It is in this context that impacts on biodiversity are assessed below.

It must also be noted that the secondary impacts on biodiversity associated with soil erosion, compaction, physical disturbance and pollution have already been assessed in Section 7.2 and will not be repeated below.

7.3.1. ISSUE: PHYSICAL DESTRUCTION OF BIODIVERSITY

TABLE 7-5: PHYSICAL DESTRUCTION OF BIODIVERSITY - LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning – cumulative	Closure – cumulative
Infrastructure establishment Soil stripping Cleaning and grubbing Preparation of the foundations Compacting bases Opening borrow pits and trenches Slope stabilization Building roads Vehicle movement Erecting power line	Mining development Vehicle movement waste management (mineralised) stockpile development Exploration	Removal of infrastructure Vehicle movement Material movement Slope stabilization	Erosion of final land forms

Assessment of impact

Introduction

With reference to Table 7-5, there are a number of activities/infrastructure in all phases that have the potential to destroy biodiversity. In this regard, the discussion relates to the physical destruction of specific biodiversity areas, of linkages between biodiversity areas and of related species.

Severity

With reference to the combined biodiversity sensitivity map that is an overlay of the three separate biodiversity sensitivity maps for vegetation, vertebrates and invertebrates (Figure 7-1), the proposed new activities are mostly located in an area of less sensitive biodiversity relative to the rest of the ML. The exception is the proposed power line that will follow the route of the existing pipeline and associated gravel track between the ML and the Swakop River. Parts of this pipeline route are situated in irreplaceable habitats (defined in Section 3.6). Despite this, the amount of disturbance that can be caused by the placement of a low voltage power line along the existing gravel track is limited, particularly in the managed scenario.

In contrast, the potential disturbance associated with the LHU approved activities is of high severity because a number of these activities (particularly those associated with the open pit mining) have been located in irreplaceable habitats and in some cases important linkages (washes and river beds used for migration of vertebrates, invertebrates and for the transport of seeds) between biodiversity areas have been and may in future be destroyed.

A further issue to consider is that once areas are disturbed invasive species are often the first to establish, which may result in a vegetation and related biodiversity imbalance.

Given the above discussion, from a cumulative LHU perspective, the unmanaged severity is high which may reduce to somewhere between high and medium depending on the successful implementation of the management measures.

Duration

In the unmanaged scenario the loss of biodiversity and related functionality is long term and will continue after the life of the mine. In the managed scenario the biodiversity and related functionality may be restored (partially or fully) during the operational and decommissioning phases.

Spatial scale

Given that biodiversity processes are not confined to the ML or the power line route to the boreholes, the spatial scale of impacts will extend beyond the site boundary in both the managed and unmanaged scenario. Key related issues are the migration of species and linkages between biodiversity areas.

FIGURE 7-1: COMBINED BIODIVERSITY SENSITIVITY MAP

Consequence

In the unmanaged scenario, the consequence of this potential impact is high. In the managed scenario this reduces to somewhere between medium and high because the severity of the impact may be reduced.

Probability

Without any management the probability of losing highly sensitive and irreplaceable biodiversity is definite. With management, the probability may be reduced because emphasis will be placed on conserving and possibly restoring or offsetting critical areas and related biodiversity. In this regard, some uncertainty remains about the realistic chances of effectively achieving either the conservation or the restoration, thus the need to consider offsetting.

Significance

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance could reduce to medium but the success of the management measures remains untested.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**H**	**H**
Managed	**M-H**	**M**	**M**	**M-H**	**M-H**	**M-H**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent the unacceptable loss of biodiversity and related functionality through physical disturbance. Given that the main components of the mining project are already approved and implemented, there may be some difficulty in achieving this objective, although there is still opportunity to plan for those sections of the mine that are yet to take place.

Actions

In the construction, operation and decommissioning phases LHU will implement its biodiversity management plan. The key components are:

- to generally limit mine infrastructure, activities and related disturbance to those specifically identified and described in this EIA report;
- where possible, to specifically avoid the disturbance of irreplaceable biodiversity areas and important linkages between biodiversity areas;

- Where a new area will be disturbed, the following will be implemented: delineation of proposed area to be disturbed, relocation of species that can effectively be relocated (especially species of conservation concern), obtain permits in terms of the Nature Conservation Ordinance 14 of 1975 and the Forest Act, 12 of 2001 for the destruction and/or removal of protected vegetation; restoration of the biodiversity functionality in areas that have been physically rehabilitated; and follow up audits and monitoring in the short and long term to determine the success of the rehabilitation and restoration activities in terms of range of performance indicators;
- implementation of an alien/invasive/weed management programme to control the spread of these plants onto and from disturbed areas;
- If irreplaceable biodiversity will be permanently lost and restoration is not possible, a biodiversity offset will be investigated. Issues that will be considered in the investigation are as follows:
    - the size of the potentially affected area;
    - the conservation/sensitivity status of the potentially affected area;
    - the offset ratio (in terms of the required size of the offset site) to be applied;
    - evaluation of alternative offset sites on the basis of: compensation for the mine's negative impact on biodiversity, long term functionality, long term viability, contribution to biodiversity conservation in the Namib including linkages to areas of conservation importance, acceptability to key stakeholders, distances from other mines in relation to dust fallout and other impacts, and biodiversity condition scores as compared to that at the LHU site;
    - land ownership now and in the future;
    - status/security of the offset site, ie. will it receive conservation status;
    - measures to guarantee the security, management, monitoring and auditing of the offset;
    - capacity of LHU to implement and manage the offset;
    - identification of unacceptable risks associated with the offset; and
    - the start up and ongoing costs associated with the offset for the life of the project.

As part of closure planning, the designs of any permanent structures (mineralised waste facilities) will take into consideration the requirements for the establishment of long term biodiversity functionality, aftercare and confirmatory monitoring.

<u>Emergency situations</u>

None identified.

7.3.2. ISSUE: REDUCTION OF WATER RESOURCES AS AN ECOLOGICAL DRIVER

TABLE 7-6: REDUCTION OF WATER RESOURCES – LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning – cumulative	Closure – cumulative
Construction of surface water containment and/or diversion infrastructure – berms, channels, dams. Borehole abstraction	Pit dewatering Backfill of mine voids and the possibility of settlement Placement of stockpiles Construction of water containment and/or diversion infrastructure – berms, channels, dams. Borehole abstraction	Pit dewatering Backfill of mine voids and the possibility of subsidence Construction of water containment and/or diversion infrastructure – berms, channels, dams. Borehole abstraction	Placement of final land forms with associated water containment and/or diversion infrastructure – berms, channels, dams Settlement in backfilled areas

Assessment of impact

Introduction

In many of the identified habitats (within and outside of the ML) a key ecological driver (an element that is important for the functioning of that habitat and related ecosystem) is water. With reference to Table 7-6, there are a number of activities/infrastructure in all phases that have the potential to reduce the availability of ground water and surface water, and change drainage patterns within and adjacent to the ML and within the Swakop River in the vicinity of the LHU abstraction boreholes.

Severity

Periodic surface water run-off and the existence of varying depths of groundwater are key ecological drivers for a range of biodiversity including highly sensitive and irreplaceable biodiversity (for example the protected *Acacia erioloba* – camel thorn).

Surface water run-off recharges the moisture content in the shallower alluvial aquifer and it promotes the downstream dispersion of seeds. In the former case, a wide range of vegetation in the washes and river beds use this moisture to sustain itself which in turn supports a range of invertebrates and vertebrates. In the latter case, seed dispersion by water is one important mechanism for the replenishment and establishment of downstream habitats. By restricting surface water flow in certain areas, these processes will be restricted.

Although specific research was not done on this issue, the consensus amongst the biodiversity specialists is that both shallow and deeper ground water resources in the Gawib and Swakop Rivers are important for sustaining larger trees despite the naturally occurring high salinity of this water. These larger trees add significant additional habitat dimensions and increase the number of niches available to both vertebrates and invertebrates. By reducing the available ground water in certain areas to below effective rooting depths (estimated at an average of between 10 and 40m depending on the type of trees, their ability to use saline water, and the ability of the roots to penetrate the harder calcrete type of layers), these larger trees my die and the associated habitats will cease to exist.

In the Swakop River, the measured water level in the abstraction boreholes is between 3 and 12m. If abstraction is in line with the recommended rates, even with a slight drawdown of approximately 1m, the impact on most trees is not expected to be significant.

In the Gawib River, the drawdown could be to depths of 50m and may extend for 5km, which may be beyond the reach of a significant number of the trees. Depending on the length of time it takes for the aquifers to re-establish this may kill the trees, some of which have taken well over a hundred years to grow to their current state.

In the unmanaged scenario, both dewatering and the obstruction of surface water run-off will occur, which has a related high severity. In the managed scenario, some aspects associated with the obstruction of surface water flow and potential dewatering can be managed. In this regard the severity reduces to somewhere between high and medium depending on the effectiveness of the management measures.

Duration

In unmanaged scenario the loss of biodiversity and related functionality is long term and will continue after the life of the mine. In the managed scenario, the reduction of water resource availability should be avoided or be temporary and therefore the impacts should be reduced.

Spatial scale

Given that biodiversity processes are not confined to the ML or to location of the pipeline/Swakop River boreholes, the spatial scale of impacts will extend beyond the site boundary in both the managed and unmanaged scenario. Key related issues are the migration of species and linkages between biodiversity areas.

Consequence

In the unmanaged scenario, the consequence of this potential impact is high. In the managed scenario this reduces to somewhere between medium and high because the severity the impact is reduced.

Probability

Without any management the probability of losing highly sensitive and irreplaceable biodiversity is definite. With effective management, the probability should be reduced because emphasis will be placed on limiting the obstruction of surface water run-off, on abstracting sustainable yields from the Swakop River boreholes, and on re-establishing the geological layers as part of mine pit rehabilitation so that the shallow and deeper aquifers can function after mining.

Significance

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance could reduce to medium but the success of the management measures remains untested.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**H**	**H**
Managed	**M-H**	**M**	**M**	**M-H**	**M-H**	**M-H**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent the unacceptable loss of biodiversity and related functionality.

Actions

In the construction, operation and decommissioning phases LHU will ensure that:

- in line with the current abstraction permit, it restricts its abstraction to 500 000m^3 per year;
- clean surface water diversion measures are provided around infrastructure and activities so that not all clean surface water flow is restricted/captured by mine infrastructure. Given physical geographical constraints, it is not possible to divert clean run-off around the mine and plant infrastructure in the centre of the ML; and
- as part of ongoing mine rehabilitation, care will be taken to re-establish functioning subsurface layers and associated aquifers as soon as possible after mining is completed in the various sections.

As part of closure planning, the designs of any permanent structures (mineralised waste facilities) will take into consideration the requirements for periodic but ecologically important surface water flow.

Emergency situations

None identified.

7.3.3. ISSUE: GENERAL DISTURBANCE OF BIODIVERSITY

TABLE 7-7: GENERAL DISTURBANCE OF BIODIVERSITY –LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning – cumulative	Closure – cumulative
General building activities Management of dirty water Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (non-mineralised) Servicing equipment	Servicing equipment Management of dirty water Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (non-mineralised) Vehicle movement on	General building activities Management of dirty water Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (non-mineralised) Equipment servicing	Seepage from remaining waste stockpiles, catchment dams and TSF

Construction for project	Operational -cumulative	Decommissioning – cumulative	Closure – cumulative
Use of vehicles and equipment that may leak lubricants and fuel Security lights Contractors camp Vehicle movement on access roads, internal roads and off road	access roads, internal roads and off road Use of vehicles and equipment that may leak lubricants and fuel Security lights Mine development Material handling Ore processing	Use of vehicles and equipment that may leak lubricants and fuel Material handling Security lights Vehicle movement on access roads, internal roads and off road	

Assessment of impact

Introduction

With reference to Table 7-7, there are a number of activities/infrastructure that have the potential to directly disturb vegetation, vertebrates and invertebrates in all mine phases, particularly in the unmanaged scenario. In the construction and decommissioning phases these activities are temporary in nature, usually existing for a few weeks to a few months. The operational phase will present more long term occurrences and the closure phase will present final land forms that may have pollution potential through long term seepage and/or run-off.

Severity

In the unmanaged scenario, biodiversity will be disturbed in the following ways:

- white light attracts large numbers of invertebrates which become easy prey for predators. This can upset the invertebrate population balances;
- people may kill various types of biodiversity for food, for sport, for fire wood etc;
- people may illegally collect and remove vegetation, vertebrate and invertebrate species;
- excessive dust fallout from various dust sources (see Section 7.7) may have adverse effects on the growth of some vegetation, particularly those that exist on the pegmatite intrusions and it may cause varying stress on the teeth of vertebrates that have to graze soiled vegetation;
- noise and vibration pollution may scare off vertebrates and invertebrates. In some instances (eg. the Mountain Zebras) the animals may be deterred from passing close to noisy activities which can effectively block some of their migration paths;
- the presence of vehicles in the area can cause road kills especially if drivers speed; and
- pollution emissions and general litter may directly impact on the survival of individual plants, vertebrates and invertebrates.

As a collective of disturbances the unmanaged severity is high because of the sensitivity of the biodiversity in the vicinity of the existing and proposed activities and because of the anticipated high number of disturbance events. In the managed scenario, most of these issues can be prevented or managed to acceptable levels, which reduces the severity to low.

Duration

In both the managed and unmanaged scenarios, the impacts are long term in nature because where biodiversity is compromised, killed or removed from the area this impact is likely to extend beyond the life of mine.

Spatial scale

Given that biodiversity processes are not confined to the ML, to the various roads or to location of the pipeline/Swakop River boreholes, the spatial scale of impacts will extend beyond the site boundary in the unmanaged and managed scenario. Key related issues are the migration of species and linkages between biodiversity areas.

Consequence

In the unmanaged scenario, the consequence of this potential impact is high. In the managed scenario, this reduces to medium because the severity of the impact is reduced.

Probability

Without any management the probability of negatively impacting on biodiversity through multiple disturbance events is high. With management, the probability will be significantly reduced because most of the disturbance types can be controlled through implementation and enforcement of practices, policies and procedures.

Significance

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance is reduced to low because the associated severity, duration and probability are reduced.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**L**	**H**	**H**	**H**
Managed	**M**	**M**	**L**	**M**	**L**	**L**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent unacceptable disturbance of biodiversity.

Actions

In the construction, operation and decommissioning phases LHU will ensure that:

- the use of light is kept to a minimum and where it is required, yellow lighting is used where possible and vertebrates are kept away from the area around the lights with appropriate fencing where possible;
- there is zero tolerance of killing or collecting any biodiversity;
- occupants of the drillers and contractors camp will remain within the camp after working hours;
- strict speed control measures are used for any vehicles driving within the Namib Naukluft park boundary;
- dust control measures are implemented (see Section 7.7) and
- pollution prevention measures are implemented (see Section 7.2.1).

As part of closure planning, the designs of any permanent and potentially polluting structures (mineralised waste facilities) will take consideration of the requirements for long term pollution prevention and confirmatory monitoring.

Emergency situations

Major spillage incidents will be handled in accordance with the LHU emergency response procedure.

Certain instances of injury to animals may be considered emergency situations. These will be managed in accordance with the LHU emergency response procedure.

7.4. RADIOLOGICAL

The information in this section was sourced from the specialist radiation study in Appendix O (NECSA 2009).

Four pathways have been considered in the assessment of radiological impacts on human health. These are discussed further below and include:

- direct external exposure to radiation from mineralised sources;
- aquatic pathway through radio-nuclides that are carried in surface and groundwater;
- atmospheric pathway through radon gas and radio-nuclides in dispersed dust; and
- secondary pathways that include: radiation from contaminated soils, ingestion of the contaminated soils, the eating of crops that are grown on radioactive contaminated land/soil, and/or eating radioactive contaminated fish and/or animals (livestock).

No assessment is provided for the potential radiological impacts on biodiversity. This is an area that generally requires additional research.

7.4.1. ISSUE: IMPACTS ASSOCIATED WITH DIRECT EXPOSURE TO RADIATION FROM ON-SITE SOURCES

TABLE 7-8: EXPOSURE TO RADIATION – LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
Ore and product Mineralised waste Non-mineralised waste	Ore and product Mineralised waste Non-mineralised waste	Ore Mineralised waste Non mineralised waste	Mineralised and non-mineralised waste

Assessment of impact

Introduction

In the context of the natural environment, radiation can occur from natural sources such as cosmic and terrestrial radiation. In the context of a mine, radiation typically originates from mineralised substances (ore, mineralised waste, uranium product) and non-mineralised radioactive contaminated waste in the form of alpha radiation, beta radiation and/or gamma radiation (see Table 7-8 for the link to mine phases). In the normal course, third party access to the final product is not possible due to very strict security measures and the product packaging prevents third party exposure to related radiation. The assessment therefore only focuses on the other potential on-site sources.

Severity

Depending on the type of radiation and third party (third parties include members of the public and occupants of the drillers and contractors camp after working hours) exposure thereto, it has the potential to physically damage human tissue and cells and cause related health impacts. In the context of the existing and proposed LHU activities/infrastructure, the typical dose associated with these sources is approximately 0.01mSv/a at 500m from the sources (NECSA 2009) which is well within the recommended 1mSv/a annual dose limit (from all sources excluding medical and natural sources) that third parties should be exposed to (International Atomic Energy Agency (IAEA), 2004 as interpreted by NECSA 2009). Closer to the sources, the doses are expected to increase. In the unmanaged scenario where third parties may have uncontrolled access to these sources over extended periods, the severity is considered to be potentially high because the doses could exceed the recommended 1mSv/a public limit (IAEA 2004). In the managed scenario, third party access is restricted, the potential doses are reduced and the severity reduces to low.

Duration

In both the unmanaged and managed scenarios, any health related impacts can be medium to long term.

Spatial scale

In both the unmanaged and managed scenarios the potential impact zone is close to the source within the ML.

Consequence

In the unmanaged scenario the consequence is high. With management the consequence reduces to medium.

Probability

In the unmanaged scenario where access to the ML is uncontrolled and third parties can come into contact with the sources, the probability of third parties experiencing radiation related health impacts is low because the dose is associated with exposure to a people on a daily basis over a year period . This probability is influenced by the fact that the ML is in a remote area where third parties are limited in number.

In the managed scenario, third party access to the radiation sources is controlled and the related probability is even lower.

It must further be noted that this assessment has assumed that the ML area will never be used for residential development. Given the situation of the ML within the Namib Naukluft Park, this is considered a fair assumption.

Significance

In the unmanaged scenario, the significance is high. With management this reduces to low because the probability and severity are reduced.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**M-H**	**L**	**M-H**	**L**	**M-L**
Managed	**L**	**M-H**	**L**	**M-L**	**L**	**L**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent radiation related health impacts.

Actions

Access to the site in general, and to the radiation sources in particular, will be restricted in all mine phases to prevent third parties from being in close proximity to radiation sources that could cause health impacts. This issue will be considered in further detail during the detailed closure planning.

The occupants of the driller and contractor camps will be contained within these camps after working hours. The camps will be sited at least 500m away from the on-site radiation sources (mineralised and non-mineralised).

All transported product will continue to be packaged and handled in a manner that third parties cannot be exposed to related radiation. Strict product related security measures will be continued.

External radiation from key sources (tailings facilities, mineralised stockpiles, open pits, and radioactive non-mineralised waste) will be monitored.

The existing LHU radiation management plan will be amended to include the findings of the EIA and the commitments in the EMP with specific attention on the management of the direct radiation sources, the related environmental monitoring requirements, and minimising doses to as low as reasonably achievable.

Emergency situations

Any spillage of substances that can expose third parties to unacceptable radiation levels will be handled in accordance with the LHU emergency response procedure.

7.4.2. ISSUE: RADIOLOGICAL IMPACTS ASSOCIATED WITH THE AQUATIC AND ATMOSPHERIC PATHWAYS

Given that these three radiological pathway assessments are closely linked to the outcomes of the potential pollution assessments for surface water, ground water and air, they have been dealt with separately in each of the following Sections:

- Surface water pathway – Section 7.5.2
- Groundwater pathway – Section 7.6.3
- Air pathway – Section 7.7.2.

7.4.3. ISSUE: RADIOLOGICAL IMPACTS ASSOCIATED WITH SECONDARY PATHWAYS

Secondary pathways where assessed as part of the groundwater pathway (Section 7.6.3) and the air pathway (Section 7.7.2). The secondary pathways include:

- ingestion of radiation contaminated soil;
- radiation exposure from contaminated soil; and
- eating crops or animals that are contaminated by radiation from water or soil

7.5. SURFACE WATER

The information in this section was sourced from the specialist surface water study in Appendix F (Metago 2008).

7.5.1. ISSUE: ALTERING DRAINAGE PATTERNS

The identified impacts associated with altering surface water drainage have been addressed in Section 7.1.1 and 7.3.2. In this regard, the two key issues are flood damage related failures of hazardous facilities that are located within or adjacent to rivers, and the loss of periodic surface water flow as an important ecological driver.

7.5.2. ISSUE: POLLUTION OF SURFACE WATER – RADIOLOGICAL AND NON-RADIOLOGICAL

TABLE 7-9: SURFACE WATER POLLUTION SOURCES–LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure – cumulative
General building activities Management of dirty water Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (non-mineralised) Equipment servicing Use of vehicles and equipment that may leak lubricants and fuel Dust fallout	Servicing equipment Management of dirty water Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (mineralised and non-mineralised) Heap leach pad Dust fallout Ore processing	General building activities Management of dirty water Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (mineralised and non-mineralised) Heap leach pad Equipment servicing Use of vehicles and equipment that may leak lubricants and fuel Dust fallout	Seepage, runoff and dust fallout from remaining mineralised stockpiles, Other waste catchment dams and TSF

Assessment of impact

Introduction

With reference to Table 7-9, there are a number of pollution sources in all phases that have the potential to pollute surface water particularly in the unmanaged scenario. This is particularly relevant because most of the existing approved infrastructure has been located within and adjacent to the various water courses. In the construction and decommissioning phases these potential pollution sources are temporary in nature, usually existing for a few weeks to a few months. Although these sources may be temporary, the potential pollution may be long term. The operational phase will present more long term potential sources and the closure phase will present final land forms that may have the potential to contaminate surface water through long term seepage and/or run-off.

<u>Severity</u>

Surface water occurs infrequently and for short durations after rainfall events. Some of this water seeps into the topsoil and shallow alluvial aquifer. The related pollution issues have been assessed as soil and shallow ground water pollution issues in Sections 7.2.1 and 7.6.2.

In some instances, flood water does travel from the ML to the Swakop River as surface water. This has been observed on at least two occasions in the past three years. During these events, the possibility exists that pollution can be carried over a few kilometres in a short space of time and may be available to biodiversity (and to a limited degree it may be available to people although the area in question is unoccupied and remote) for short term use.

In the unmanaged scenario, surface water may collect contaminants (hydrocarbons, salts, chemicals, metals, radio-nuclides, and decay/daughter products) from numerous sources. At elevated pollution concentrations these contaminants can be harmful to humans if ingested directly or indirectly through contaminated vegetation, vertebrates and invertebrates. Impacts on biodiversity have been assessed in Section 7.3.3 and will not be reassessed in this section. The dilution effect of the flood water has not been studied in detail but it will reduce the concentration of any contaminants. Given the variability around the flood water pollution chemistry this is assumed to be a potentially high severity until modelling and/or monitoring can show otherwise.

In the managed scenario, most surface water run-off should be relatively clean and the severity reduces to low because:

- by implementing a system where the dirty areas will be isolated from clean run-off and dirty water is contained and reused rather than discharged into the environment, and
- by implementing dust control measures the fallout of dust that can be collected and pollute surface water should also have been managed to acceptable levels.

<u>Duration</u>

The frequency and duration of the flood events are limited, but the potential health impacts, particularly for humans in the unmanaged scenario, are long term. In the management scenario, the duration of any impacts is considered to be medium to short term because the water should not be polluted and there should not be significant related health risks.

<u>Spatial scale</u>

The spatial scale of the potential impacts will be restricted to potential surface water use in the Gawib and Swakop River systems, for as far as the surface water travels before it evaporates or seeps into the alluvial aquifer.

<u>Consequence</u>

In the unmanaged scenario, the consequence of this potential impact is high. In the managed scenario, this reduces to low because the severity and duration of the impacts is reduced.

<u>Probability</u>

Without any management the probability of impacting on human health through pollution events is medium to low because the surface water will be in remote areas that are not frequented by humans and it is only on surface for a short period of time. With management, the probability will be further reduced because, the emphasis will be placed on preventing the pollution of surface run-off, capturing dirty water in the process water circuit and on quick and effective remediation if pollution events do occur. In this regard, the potential impacts from recent flood events have been managed by capturing most of the upstream flood water in the open pit that is located to the east of the processing plant and by capturing dirty run-off from the plant area in the process water dam.

<u>Significance</u>

In the unmanaged scenario, the significance of this potential impact is medium. In the managed scenario, the significance is reduced to low because of the reduction in severity, duration and probability.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**L**	**M**
Managed	**L**	**M**	**M**	**L**	**L**	**L**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

<u>Objective</u>

The objective of the management measures is to prevent pollution of surface water run-off.

<u>Actions</u>

In the construction, operation and decommissioning phases LHU will ensure that:

- all hazardous chemicals (new and used), dirty water, mineralised wastes and non-mineralised wastes are handled in a manner that they do not contaminate surface water run-off or where this is not possible LHU will demonstrate (through additional modelling and/or monitoring) that the potential contamination is within acceptable limits from a human health and related risk perspective. Further detail is provided in Section 7.2.1;

- where possible, surface water management facilities will be designed, constructed and operated so that dirty water is kept separate from clean water run-off through a system of berms, channels, trenches, flood protection measures, erosion protection and dams;
- It is likely that the flood water that is captured in the upstream open pit will be contaminated by residues in the pit and this could pollute the deeper paleo-channel aquifer. It follows, that as part of the surface water management system, the open pit will be lined to prevent ingress of dirty water. Details on the liner options are provided in Section 7.6.2;
- the existing operational site wide water balance will be revisited taking rainfall, run-off and the proposed additional processes (such as the heap leach pad) into account to ensure that the design of the relevant clean and dirty water systems are sufficient to cater for the water volumes associated with the infrequent flood events and that unacceptable discharges of polluted water are prevented; and
- where rainfall related discharges occur, LHU will monitor the surface water discharge quality (non radiological and radiological). If the quality of the monitored discharge is above acceptable levels, additional measures will be identified and implemented to prevent the future potential for surface water related pollution.

The existing LHU radiation management plan will be amended to include the findings of the EIA and the commitments in the EMP with specific attention on the management of the radiological surface water pathway, the related environmental monitoring requirements, and minimising doses to as low as reasonably achievable.

As part of closure planning, the designs of any permanent and potentially polluting structures (mineralised waste facilities) will consider the requirements for long term surface water pollution prevention and confirmatory monitoring.

Emergency situations

Major spillage incidents that contaminate flood waters will be handled in accordance with the LHU emergency response procedure.

7.6. GROUNDWATER

The information in this section was sourced from the specialist groundwater study in Appendix J (BIWAC 2009) and the specialist radiological study in Appendix O (NECSA 2009).

7.6.1. ISSUE: WATER ABSTRACTION IMPACTS ON THIRD PARTY USERS

TABLE 7-10: LOWERING OF GROUNDWATER LEVELS – LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
Borehole abstraction	Pit dewatering Borehole abstraction	Pit dewatering Borehole abstraction	N/A

Assessment of impact

Introduction

With reference to Table 7-10, there are two activities that have the potential to reduce the local groundwater level: dewatering of the pits in the ML and borehole abstraction in the Swakop River. Both activities will cease in the decommissioning phase. The impacts on biodiversity have been assessed in Section 7.3.2 therefore this section will focus on third party groundwater users.

Severity

One area of particular concern to third parties is LHU's existing approved groundwater abstraction from boreholes in the Swakop River. This is a concern to farmers that abstract groundwater from the Swakop River alluvium 50km downstream of the LHU abstraction area and to farmers that abstract groundwater for domestic use and livestock watering from the fractures in the basement rocks on farms outside the Namib Naukluft Park, to the north of the LHU abstraction area (the closest farm where such abstraction takes place is Modderfontein – see Figure 1-2). The farmers' concerns stem from the viewpoint that water is a scarce resource in the Namib and a loss or reduction of the groundwater resource would impact on their livelihoods.

The measured water level in the LHU abstraction boreholes is between 3 and 12m below surface. The specialist groundwater study (BIWAC 2009) predicts that in both the managed and unmanaged scenario, LHU abstraction activities will only cause a drawdown in the water table in that specific confined compartment (approximately 20km long) of the Swakop River. If the abstraction is in line with the permit volumes, the predicted drawdown in groundwater levels in the specific compartment is approximately 1m (no modelling has been done to predict the magnitude of the drawdown in the compartment if the permit volumes are exceeded). To date, LHU has abstracted significantly less than the permit allocation.

There is no predicted impact on the Swakop River farmers that are located 50km downstream of the LHU abstraction boreholes because they abstract water from another compartment in the Swakop River. The groundwater specialist has also noted that groundwater users on farms to the north of the LHU abstraction boreholes rely on fractures in the basement rocks and not on the shallow alluvial aquifer of the Swakop River. With the predicted drawdown of 1 m and the low permeabilities of the basement rocks, it is further predicted that the LHU abstraction activities will not cause a noticeable drop in borehole water levels of the groundwater users to the north.

In the Gawib River, the drawdown in ground water levels from pit dewatering could be to depths of 50m and may extend up to 5km from the dewatering activities (BIWAC 2009). This will not extend to zones that could impact on third party groundwater users and will not extend to the confluence of the Gawib and Swakop Rivers.

In the managed scenario, where LHU complies with the permit conditions, the severity is low because no impacts have been predicted. In the unmanaged scenario where the permit conditions are exceeded, the severity is also likely to be low because the LHU abstraction activities are predicted to have a localised impact only, but because there is no confirmatory modelling, a medium severity has been assigned as a precautionary measure.

Duration

The localised groundwater levels are expected to recharge within a few years of decommissioning the abstraction and dewatering activities. In the managed scenario, the duration of impacts on third parties is not relevant because no impact has been predicted. In the unmanaged scenario, a medium duration has been applied as a precautionary measure.

Spatial scale

In the managed and unmanaged scenario the drawdown and related potential for impacts will be localised, but may extend beyond the ML boundary. This is a medium spatial scale.

Consequence

In the unmanaged scenario the consequence is medium, In the managed scenario, the consequence is low.

Probability

This probability of third party groundwater users suffering a loss of water through LHU's abstraction and dewatering activities is highly unlikely in the managed scenario. In the unmanaged scenario, the probability is also limited because the LHU abstraction activities should be confined to the specific compartment in the Swakop River alluvial aquifer. Notwithstanding this, in the absence of modelling for the unmanaged scenario, a medium probability has been assigned as a precautionary measure.

Significance

In the unmanaged and managed scenario, the significance of this potential impact is low.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**M**	**M**	**M**	**M**	**M**	**M**
Managed	**L**	**L**	**M**	**L**	**L**	**L**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent the loss of groundwater to farmers in the region.

Actions

In the construction, operation and decommissioning phases LHU will ensure that, in line with the permit, it restricts its abstraction to 500 000m^3 per year.

LHU will monitor the water levels in the Swakop River, up and down stream of the abstraction boreholes. In addition, the boreholes of the closest third party farmers to the north of the abstraction boreholes will be monitored on request. If this monitoring indicates an LHU related decrease in groundwater supply to third parties, appropriate measures will be taken to prevent the decrease from occurring and/or to provide the affected third parties with an alternative water supply.

LHU will ensure that its permits, in terms of the Water Act of 1956, for abstraction and pit dewatering are renewed as required.

Emergency situations

None identified.

7.6.2. ISSUE: CONTAMINATION OF GROUNDWATER – NON RADIOLOGICAL

TABLE 7-11: CONTAMINATION OF GROUNDWATER –LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (non-mineralised) Sanitation Servicing equipment	Mining development Ore processing Heap leach pad Servicing equipment Dirty water management and related facilities Storage and handling of new and used materials and chemicals (including	Servicing equipment Storage and handling of new and used materials and chemicals (including hydrocarbons) Waste management (mineralised and non mineralised) Sanitation	Remaining infrastructure – surface water management system, TSFs, other mineralised stockpiles and other wastes

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
	hydrocarbons) Waste management (mineralised and non-mineralised) Stockpile development Sanitation Pipelines	Slope stabilization Stockpiles and waste facilities Dirty water management and related facilities	

Assessment of impact

Introduction

With reference to Table 7-11, there are a number of sources in all phases that have the potential to pollute groundwater particularly in the unmanaged scenario. In the construction and decommissioning phases these potential pollution sources are temporary and diffuse in nature, usually existing for a few weeks to a few months. Even though the sources are temporary in nature, related potential pollution can be long term. The operational phase will present more long term potential sources and the closure phase will present final land forms that may have the potential to pollute water resources through long term seepage and/or run-off.

Severity

In the unmanaged scenario, pollution of groundwater from numerous pollution sources has the potential to negatively impact downstream biodiversity and human users. The potential impacts on biodiversity have been discussed in Section 7.3 therefore this assessment focuses on potential impacts on downstream water users such as the farmers that are located approximately 50km downstream of the ML on the Swakop River.

Two types of pollution sources are broadly considered. The one type is diffuse pollution which includes ad hoc spills and discharges of polluting substances. The other type is point source pollution which includes more long term pollution associated with longer term structures such as mineralised stockpiles, the proposed heap leach pad and the approved aboveground and in-pit TSFs. In this regard, the groundwater specialist has identified that the most significant potential pollution is associated with the approved aboveground and in-pit tailings, which has both radiological and non-radiological components. An analysis of the current temporary TSF return water (that is considered indicative of the permanent TSF seepage water) presents a number of pollution parameters that can have significant human health impacts depending on how they are transported from the pollution source and at what concentrations they might occur in areas where people have access to groundwater. While the acid based accounting tests (included as an appendix in the groundwater specialist report -see Appendix J) showed no material potential for acid mine drainage form the TSF or any of the mineralised stockpiles, the potential pollution parameters are numerous and include: hydrocarbons, salts, chemicals, metals, radio-nuclides and their daughter decay products.

The groundwater specialist report presents modelled results for uranium because this is considered by the specialists to be soluble and mobile and the main concern in the context of the mine related impacts. In certain conservatively modelled scenarios, without management measures, the predicted mine related uranium concentrations could be as much as 2mg/l at the confluence of the Gawib and the Swakop River. Although this is within the 4mg/l Namibian drinking water guideline range for good quality water (Water Affairs 1988), it exceeds both the South African irrigation guideline of 0.01 mg/l (Department of Water Affairs and Forestry, 1996) and the World Health Organisation drinking water guideline of 0.015 mg/l (WHO 1984). This issue must be understood in the context of two further issues. Firstly, the existing natural background concentration of uranium in the Swakop River at that point is approximately 0.11 mg/l (already above the two international guidelines). Secondly, no modelling has been done to further predict the extent and concentration of the potential pollution plume in the Swakop River. In this regard, it is not known whether water in the upper Swakop River can actually migrate all the way down to the area where the famers are located, and if it can, the uranium concentration is likely to be further diluted. A further unknown is whether the water is used only for irrigation or also for domestic use and drinking. Despite the unknown issues, a precautionary approach has been adopted such that if the 2mg/l is consumed by humans this has potential health related impacts which in the unmanaged scenario is rated as a potential high severity.

In the managed scenario, most of the diffuse pollution sources will be eliminated (see management actions in Section 7.2.1) and a number of design and operational interventions should significantly reduce the point source pollution potential and prevent any ground water pollution plumes from leaving the ML and reaching areas that are or may in future used by third parties. Depending on the effectiveness of these management measures and the actual exposure of humans to pollution of consequence, the severity may reduce to low.

<u>Duration</u>

In both the unmanaged and managed scenarios, if human health impacts occur, these are potentially serious and long term in nature.

<u>Spatial scale</u>

The spatial scale of the potential impact is directly related to the spatial scale of the dispersion of any ground water pollution that in turn has the potential to impact on human health. In the unmanaged scenario, it is assumed that groundwater pollution may travel outside of the ML via the shallow alluvial aquifer, the deeper paleo-channel aquifer and/or fractures and faults in the basement rock. The specialist study has indicated that water flow in the alluvial aquifer and the basement faults and fractures is to the north west towards the Swakop River, with flow in the paleo-channel aquifer being more to the west and ultimately towards the general direction of the Atlantic Ocean.

Given the known average permeability of the three aquifers, the study predicts that pollution will move the fastest in the shallow alluvial aquifer and slowly in the paleo-channel aquifer. In the very conservative unmanaged scenario, where a constant discharge into the alluvial aquifer is modelled and where the effect of pit dewatering is not taken into account during the operational phase, pollution may reach the confluence of the Gawib and Swakop Rivers (approximately 12km from the ML) within 12 years from the commencement of the pollution point source. Although this is still approximately 35km upstream of the closest water user (farmers), in time, with the same conservative scenario of a constant discharge and assuming that there are no barriers to downstream flow in the Swakop River, the pollution may travel the additional distance at approximately 1km per year.

In the managed scenario, it is predicted that most of the contamination will be contained on-site in the long term.

Consequence

In the unmanaged scenario, the consequence of this potential impact is high. In the managed scenario, this reduces to medium because the severity and spatial scale of the impact is reduced.

Probability

Without any management the probability of off-site pollution from both diffuse and point sources is high. Whether this will result in human health impacts depends on the extent of the pollution plume, the concentration of the different pollution parameters such as uranium, and the exposure of humans to the pollution both in terms of their own health profiles and the nature of their exposure to the polluted water. As discussed above, the unknowns in the modelling relate to the potential for the pollution plume to migrate down the Swakop River and reach the area where the farmers are located, and to the dilution effect that this distance will have. A further unknown is whether any farmers abstract this water for domestic use and drinking. In this regard, it is a confirmed source of water for crop irrigation, but not necessarily for domestic use and drinking. On balance, the unmanaged probability of a health impact being caused to humans is considered to be medium.

With management, the probability will be further reduced because emphasis will be placed on preventing pollution events and on containing pollution to within the ML. In support of this possibility is the fact that the specialist has noted that all pollution from the existing temporary TSF has been contained close to source and within the ML by means of a cut-off trench and associated abstraction pumps. No groundwater pollution has been measured beyond this trench.

One significant difference in the future operational, decommissioning and closure scenario is that some of the tailings will have been placed into the mined out pits which presents the possibility that the paleo-channel aquifer and basement faults and fractures may be contaminated and/or the functionality of the paleo-channel aquifer may be lost which forces pollution upwards to the shallower and more permeable alluvial aquifer. Additional engineering solutions have been proposed for the managed scenario and these include a range of liners, passive barriers and seepage collection measures. The long term post closure performance of these measures is however untested.

Significance

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance could reduce to low but the success of the management measures remains untested.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**M**	**H**
Managed	**L**	**H**	**L**	**M**	**M-L**	**M-L**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent unacceptable groundwater pollution related impacts.

Actions

Additional specialist work should include the following:

- once the final configuration of the post closure mineralised waste stockpiles is understood, the stockpile(s) should be considered as potential long term pollution sources and additional modelling should be done for these sources;
- even though the pollution risks are considered low in the managed scenario, further modelling should be done to understand the potential for downstream pollution movement, dilution in the Swakop River, and the nature of the downstream water abstraction and use;
- the relevant specialists must also confirm whether there are any other potential pathways (via the deeper paleo-channel and/or fractures/faults) through which groundwater pollution may present a human health risk. If necessary these should also be modelled.

If the results of this additional specialist work indicate that there may be additional and/or more significant potential impacts, some of the actions included below may have to be revisited although they have been recommended based on a precautionary approach and are expected to cover the necessary scenarios.

In the construction, operation and decommissioning phases LHU will ensure that all hazardous chemicals (new and used), dirty water, mineralised wastes and non-mineralised wastes are handled in a manner that they do not pollute groundwater (see Section 7.2.1 for specific actions).

The recommendations by the tailings design engineer (Appendix P) will be implemented for both the aboveground and in-pit tailings. The main points are:

- reducing the ability of the tailings to emit liquid pollution by increasing the density and lowering the tailings water content. This will be done with the proposed thickener;
- containing any polluted seepage by means of impermeable liners that comprises compacted calcrete possibly in combination with an impermeable synthetic liner;
- In the case of the in-pit tailings disposal, the liner(s) will be placed above, on the sides and below the tailings material which will prevent seepage into and out of the tailings deposition zone; and
- collection and reuse of excess seepage, rainfall and run-off water by means of collection and pumping facilities.

The detailed design of the heap leach pad will incorporate the principles for pollution prevention that have been described in Section 6.2.4. These measures include multiple impermeable liners, leak detection and collection for the pads, trenches and solution ponds.

During the operation phase, care will be taken to not mine through the bottom of the deeper paleo-channel aquifer into the basement material. Ideally a buffer zone of paleo-channel aquifer material should be left un-mined, alternatively or in parallel, care will be taken to recreate the paleo-channel aquifer so that aquifer flow can continue and that blocked water does not move up through the tailings deposition zone and seep pollution into the more permeable shallow alluvial aquifer.

In cases where mined out areas are immediately beneath the main channel of the Gawib River, backfilling will not contain tailings unless the impermeable layers (as discussed above) are definitely going to prevent flood water from the river channel from draining from the shallow alluvial aquifer into the deeper paleo-channel aquifer.

In all mine phases, groundwater monitoring will be performed to confirm the upstream, on-site and downstream water qualities in all three aquifers covering all possible flow directions. In this regard, additional upstream boreholes will be located in the Gawib, to the east and south of the ML and additional boreholes will be located in the paleo-channel aquiver downstream of the ML to the west. If monitoring identifies off-site contamination then a remediation plan will be implemented in consultation with an appropriate specialist and the relevant authorities, such that third parties are not exposed to the pollution and related potential health impacts. Options for remediation would include the capture and treatment of polluted water.

As an additional prevention or remediation option, investigation will take place on the merits of installing an underground reactive passive barrier (eg. iron oxide) at a downstream point on the relevant aquifer channels that could capture some seepage contaminants and prevent them from migrating further downstream to the Swakop River.

As part of closure planning, the designs of any permanent and potentially polluting structures (mineralised waste stockpile facilities) will take consideration of the requirements for long term pollution prevention and confirmatory monitoring.

Emergency situations

Major spillage incidents will be handled in accordance with the LHU emergency response procedure.

7.6.3. ISSUE: CONTAMINATION OF GROUNDWATER –RADIOLOGICAL

Assessment of impact

Introduction

With reference to Table 7-11, there are a number of sources in all phases that have the potential to pollute groundwater particularly in the unmanaged scenario. The groundwater pollution pathway is most relevant to the aquatic transport of radio-nuclides and therefore the related assessment discussion in Section 7.6.2 applies and must be read together with this Section.

As discussed in Section 7.6.2, the conservative groundwater model prediction is that in the unmanaged scenario, a pollution plume containing 2mg/l of uranium may in future reach the confluence of the Gawib and Swakop Rivers. There are no groundwater users at this point (the closest users are an additional 35km downstream), therefore a hypothetical scenario was postulated by the radiological specialist (NECSA 2009) to assess the impacts if groundwater users were in future located at the Gawib/Swakop confluence.

The assessment below focuses on the human health impacts of groundwater related radioactivity through drinking of polluted water, soil ingestion, eating of food grown on contaminated (through irrigation and/or deposition) land, and/or eating water contaminated vertebrates and/or invertebrates.

Severity

In the unmanaged scenario, the predicted radioactive dose is derived from the conservatively predicted uranium concentration at the Gawib/Swakop confluence. In this regard, the predicted 2mg/l uranium is associated with a calculated total radioactivity level. This radioactivity is converted to an effective dose by using the relevant dose coefficients (used to convert radioactivity to doses) that are applicable to all third party age groups (from infants to adults). The end result is that the 2mg/l of uranium corresponds to a 3.4 mS/a effective dose. This exceeds the recommended 1mS/annum public exposure limit (IAEA 2004 as interpreted by NECSA 2009) and therefore presents potential health impacts. The related impact severity is high in the unmanaged scenario.

In the managed scenario, the potential uranium pollution is contained within the ML which means that the effective dose at the Gawib/Swakop confluence will be similar to the current natural background dose of 0.16mS/annum (see Section 3.11.2). The mine related impact severity therefore reduces to low.

Duration

In the managed and unmanaged scenarios, if the potential health impacts do occur they are expected to be medium to long term in nature.

Spatial scale

In the unmanaged scenario the potential impacts may extend to the Swakop/Gawib confluence and beyond depending on the effect of dilution and on the potential for the pollution to travel down the Swakop River. In the managed scenario, the potential impacts will be contained within the ML.

Consequence

In the unmanaged scenario the consequence is high. In the managed scenario the consequence reduces to medium because the severity and spatial scale are reduced.

Probability

Without any management the probability of off-site uranium pollution is high. Whether this will result in radioactive related human health impacts depends on the extent of the pollution plume, the concentration of the uranium, and the exposure of humans to the pollution both in terms of their own health profiles and the nature of their exposure to the polluted water. As discussed in Section 7.6.2, the unknowns in the groundwater modelling relate to the potential for the pollution plume to migrate down the Swakop River and reach the downstream area where the farmers are located, and to the dilution effect that this distance will have. A further unknown is whether any farmers abstract this water for domestic use and drinking. In this regard, it is a confirmed source of water for crop irrigation, but not necessarily for domestic use and drinking. On balance, the unmanaged probability of a health impact being caused to humans is considered to be medium.

With management, the probability will be further reduced because emphasis will be placed on preventing pollution events and on containing pollution to within the ML. As has been noted in Section 7.6.2, the long term post closure performance of these measures is however untested.

Significance

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance could reduce to low but the success of the management measures remains untested.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**M**	**H**
Managed	**L**	**H**	**L**	**M-**	**M-L**	**M-L**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent unacceptable groundwater pollution related impacts.

Actions

In addition to the actions discussed in Section 7.6.2:

- a radiological assessment component will be applied to the additional groundwater modelling work; and
- monitoring of the radio-nuclide content of water will be performed as part of the groundwater monitoring programme.

The existing LHU radiation management plan will be amended to include the findings of the EIA and the commitments in the EMP with specific attention on the management of the radiological groundwater pathway, the related environmental monitoring requirements, and minimising doses to as low as reasonably achievable.

Emergency situations

Major spillage incidents that have the potential to pose radioactive related impacts will be handled in accordance with the LHU emergency response procedure.

7.7. AIR QUALITY

The information in this section was sourced from the air specialist study in Appendix G (Airshed 2009) and the radiological specialist study in Appendix O (NECSA 2009).

TABLE 7-12: AIR POLLUTION SOURCES – LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
Soil stripping Cleaning and grubbing Preparation of the	Soil stripping Overburden removal Drilling and blasting	Removal of infrastructure Vehicle movement and exhaust fumes	Remaining infrastructure – surface water management system, TSFs and other mineralised stockpiles

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
foundations Compacting bases Opening borrow pits and trenches General building activities Slope stabilization Building roads Vehicle movement and exhaust fumes Diesel generators	Crushing and screening Vehicle movement and exhaust fumes Soil management activities Waste and heap leach management (mineralised) Stockpile development Conveyors Diesel Generators General materials handling	General material handling Soil management activities General building activities Waste management (mineralised) Slope stabilization Diesel Generators	Vegetation establishment and maintenance

7.7.1. ISSUE: AIR POLLUTION – NON-RADIOLOGICAL

Assessment of impact

Introduction

With reference to Table 7-12, there are a number of sources in all phases that have the potential to pollute the air. In the construction and decommissioning phases these potential pollution sources are temporary in nature, usually existing for a few weeks to a few months. The operational phase will present more long term potential sources and the closure phase will present final land forms that may have the potential to pollute the air through long term wind erosion.

Pollution related impacts on biodiversity have been discussed in Section 7.3.3 and therefore this section focuses on human health impacts.

Severity

The main emissions include: inhalable particulate matter less than 10 microns in size (PM10), larger total suspended particulates (TSP), and limited gas emissions. The inhalable components can cause human health impacts at high concentrations over extended periods, while the larger particulate component can cause nuisance dust impacts such as soiling of grazing veld at high fallout quantities over extended periods. In order to determine the potential for health and nuisance impacts the following set of health and nuisance related standards, guidelines and limits have been used (full details and references are provided in Airshed 2009, Appendix G):

- European Community (EC) daily (50 microgram/m^3) and annual PM10 (40 microgram/m^3) standards;
- World Health Organisation (WHO) daily (between 50 and 150 microgram/m^3) and annual PM10 (between 20 and 70 microgram/m^3) guidelines and targets; and
- South African (600mg/m^2/day) and German (350mg/m^2/day) TSP limits and standards for residential and general areas respectively.

Other emissions types (particularly from the on-site diesel generators and vehicle exhaust fumes) were considered to be less significant than PM10 and TSP from an impact perspective. This holds true provided that the relevant International Finance Corporation (IFC) emission limits for the diesel generators are adhered to. The relevant parameters and limits are sulphur dioxide (SO_2 – emission limit of 1.5% to 3%), oxides of nitrogen (NO_x – emission limit of between 1.460 to 1.850 mg/Normal m^3) and diesel particulate matter (DPM – emission limit of 50mg/Normal m^3). Further details and references are provided in Airshed 2009, Appendix G.

The air specialist made use of a theoretical model to conservatively predict air quality impacts. In this regard, all mine phases present air pollution related impacts and the most significant mine phases are the construction phase (which comprises proposed construction emissions together with the current situation) and cumulative operational phase. In this regard, the modelled operational phase impacts includes simulations for different mining areas some of which are further away from the centroid of activities on site which increases emissions related to dust entrainment on roads and materials handling.

In the unmanaged/partially managed scenario (where modelling assumed a basic level of dust control), incremental and cumulative TSP and PM10 concentrations were predicted by modelling to exceed relevant standards and guidelines to varying degrees both on and off-site. The relevant receptor points that were considered include the temporary contractors camp (after working hours these contractors are considered to be third parties) that will no longer be a receptor during the operational phase (on-site), the on-site drillers camp (after working hours these drillers are considered to be third parties) and Bloedkoppie (off-site). Each aspect is discussed further below.

PM10 model predictions

In the unmanaged construction phase (12 month period), the daily standards and guidelines are exceeded at all three receptor points. The annual standards and guidelines are generally exceeded at the on-site receptors, but generally not exceeded at Bloedkoppie.

In the partially managed operational phase (where modelling assumed a basic level of dust control), the daily standards and guidelines are exceeded at both the drillers camp and at Bloedkoppie. The exceedances are more significant as the mining moves towards the east. All of the annual standards and guidelines are exceeded at the driller's camp but only some of them are exceeded at Bloedkoppie

TSP model predictions

In the unmanaged construction phase, TSP levels exceed the German standard at the on-site receptors only, but there is no exceedance of the South African limit at either the on or off-site receptors.

In the partially managed operational phase, TSP levels exceed both the German standard and the South African limit at both the drillers camp and at Bloedkoppie.

If considered in isolation the implication of exceeding the various standards, guidelines, targets and limits is that there will be human health impacts. However, in context, the main exposure to third parties will be at Bloedkoppie and this is very limited because visitors are unlikely to stay at the Bloedkoppie campsite for more than a few days in any given year. It follows that the number of daily exceedances that visitors may be exposed to will fall within the accepted allowable number of daily exceedances (as prescribed in the international standards and guidelines) for the average person.

In addition, the exposure to residents at the drillers camp and the contractors camp is both temporary (because residents at either facility are not permanent and in the case of the contractors camp it is a temporary facility) and it reduces at night when construction and operational activities reduce and the occupants are effectively off-duty third parties. Therefore, in the unmanaged scenario the severity is medium.

This may further reduce for the Bloedkoppie area in the managed scenario but is unlikely to change for the drillers camp.

Duration

In both the unmanaged/partially and managed scenarios, if human health impacts occur, these are potentially serious and long term in nature.

Spatial scale

The spatial scale of the potential impact is directly related to the spatial scale of the dispersion of any air pollution that in turn has the potential to impact on human health. In the unmanaged/partially managed scenarios, the potential impacts extend beyond the site boundary. In the managed scenario, the potential for off-site impacts may be eliminated.

Consequence

In the unmanaged/partially managed and managed scenario, the consequence of this potential impact is high. In the managed scenario, this reduces to medium because the spatial scale of the potential impact is reduced.

Probability

With partial or no management the probability of off-site pollution from both diffuse and point sources is high. Whether this will result in human health impacts depends on the extent of the pollution plume, the concentration of the different pollution components, and the exposure of humans to exceedances of the relevant standards, guidelines, targets and limits. As has been discussed, it is unlikely that visitors to Bloedkoppie will be exposed to unacceptable exceedance events and therefore the probability is low. With management, the probability will be further reduced because the emphasis will be placed on containing exceedances to within the ML.

In the case of workers that reside in the contractor and drillers camp, the probability increases but only marginally because of the fact that the residents are not full time residents, the contractors camp will only exist for 12 months, and the concentrations will generally be less at night (the time that residents are at the facilities and could be considered as off duty third parties) because the number of polluting activities will generally reduce.

<u>Significance</u>

In the partially managed scenario, the significance of this potential impact is high. In the managed scenario, the significance is reduced to between medium and low because the spatial scale and probability are reduced.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged / partially managed	**M**	**H**	**M**	**H**	**M**	**H**
Managed	**M**	**H**	**L**	**M**	**L-M**	**L-M**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

<u>Objective</u>

The objective of the management measures is to prevent unacceptable air quality related pollution impacts.

<u>Actions</u>

In the construction, operational and decommissioning phases, additional management measures will be implemented for the main impact source: dust entrainment on unpaved roads. The recommended methods to achieve this are:

- dust suppression on roads through chemical binding agents and/or water sprays;
- reduction in dust entrainment on unpaved roads by limiting vehicle speeds;
- considering ways to reduce vehicle movement on unpaved roads (eg. travel once with a full load instead of twice with a half load);

The exposure to air quality related impacts of residents of the drillers camp will be monitored and the position of the drillers camp and the length of stays of the drillers will be revisited if necessary.

As part of closure planning (which has already commenced in concept), the designs of any permanent and potentially polluting structures (mineralised waste facilities) will consider the requirements for long term pollution prevention and confirmatory monitoring. Implementation of these designs will take place during the construction phase of all new facilities.

A monitoring programme, to confirm the actual TSP and PM10 concentrations, will be implemented for all project phases covering:

- source based performance indicators;
- a network of fallout buckets for monitoring TSP;
- an ambient monitor for PM10;
- meteorological monitoring; and
- audits and inspections.

Depending on the results of the monitoring, the management actions may need to be revised.

The diesel generators will be operated and maintained according to supplier specifications and the International Finance Corporation (sourced from Airshed 2009) emission limits.

Emergency situations

None identified.

7.7.2. ISSUE: AIR POLLUTION –RADIOLOGICAL

Assessment of impact

Introduction

With reference to Table 7-12, there are a number of sources in all phases that have the potential to pollute the air. This air pollution pathway is also relevant to the transport of radon gas and radio-nuclides (as a component of dust). The information in Section 7.7.1 is relevant to the assessment in this Section. The assessment below focuses on human health impacts of air quality related radioactivity.

Severity

Radon gas and dust related radio-nuclide emissions were calculated by the radiological specialist (NECSA 2009) using a combination of general and site specific data. This information was converted to an effective dose by using the relevant conversion factors and dose coefficients (used to convert gas concentration and radioactivity to doses) that are applicable to all third party age groups (from infants to adults).

The predicted results and related severity are discussed separately for Radon gas, PM10 and TSP. In this regard, the specialist (NECSA 2009) has presented the following criteria as a basis for the assessment of severity:

- doses below 10 micro Sievert/annum are trivial and of no concern for health related impacts;
- doses below 300 micro Sievert/annum are below the source constraint for LHU and are considered as low risk for health related impacts;
- doses between 300 and 1000 micro Sievert/annum are below the public dose limit but are of medium risk for health related impacts; and
- doses above 1000 micro Sievert/annum are above the recommended 1mSv/a public dose limit (IAEA 2004 as interpreted by NECSA 2009) and are considered as high risk for health related impacts.

Radon dose predictions

The predicted doses for third parties at Bloedkoppie (that were assumed to stay there for seven consecutive days), and for workers that stay at the drillers camp and contractors camp after hours are considered to be trivial because they are less than 10 micro Sievert/annum. The related severity is low in the managed and unmanaged scenario.

PM10 dose predictions

In the partially managed scenario, the assessed dose for third parties at Bloedkoppie is considered trivial because it is less than 10 micro Sievert/annum. In the case of the drillers camp and contractors camp, the assessed dose is considered to be low at below 46 and 43 micro Sievert/annum respectively. The related severity is low in the partially managed and managed scenarios.

TSP dose predictions

In the partially managed scenario, the assessed dose for third parties at Bloedkoppie is considered trivial because it is less than 10 micro Sievert/annum. In the case of the drillers camp and contractors camp, the assessed dose is considered to be low at 114 and less than 10 micro Sievert/annum respectively. The related severity is to low in the partially managed and managed scenarios.

<u>Duration</u>

If human health impacts associated with the predicted doses occur, these are considered to be medium to long term in nature. This applies to both unmanaged and managed scenarios.

<u>Spatial scale</u>

The predicted doses and related impacts from the air pathway are unlikely to extend beyond the ML in the unmanaged and managed scenarios.

<u>Consequence</u>

In the both the partially and managed scenario, the consequence is low.

Probability

In both scenarios, there is low probability of any off-site exposure to third parties. In the partially managed scenario and managed scenario, there is limited possibility that occupants of the drillers camp and the contractors camp may be exposed to doses that could cause health impacts. Management measures will further reduce this possibility.

Significance

In both scenarios the significance of this impact is low.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged / partially managed	**L**	**H**	**L**	**M**	**M-L**	**M-L**
Managed	**L**	**H**	**L**	**M**	**L**	**L**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent unacceptable air quality related pollution impacts.

Actions

In addition to the actions described in Section 7.7.1, the environmental monitoring programmes will be expanded to cover:

- the radio-nuclide components of the TSP and PM10;
- radon gas emissions concentration and rates (flux) from key sources (tailings facilities, mineralised stockpiles, open pits, radioactive non-mineralised waste) that can be used to validate the generic default values in the specialist report (NECSA 2009);
- additional sampling of the radionuclide content of the relevant radioactive dust sources to validate the data used by NECSA and to assist with closure planning; and
- ambient radon gas concentrations in and adjacent to the ML.

These environmental monitoring programmes will augment the radiological monitoring that LHU currently undertakes from an occupational health and safety perspective.

The existing LHU radiation management plan will be amended to include the findings of the EIA and the commitments in the EMP with specific attention on the management of the radiological air pathway, the related environmental monitoring requirements, and minimising doses to as low as reasonably achievable.

Emergency situations

None identified.

7.8. NOISE

7.8.1. ISSUE: NOISE POLLUTION

TABLE 7-13: NOISE POLLUTION – LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
Generators Vehicle movement Earth moving equipment General building activities	Drilling Blasting Earth moving equipment material tipping Vehicle movement Crushing General operational activities Generators	Vehicle movement Earth moving equipment Material tipping Stripping of buildings and equipment Generators	N/A

Assessment of impact

Introduction

With reference to Table 7-13, there are a range of construction, operation and decommissioning activities that have the potential to generate noise and cause related pollution. Potential noise impacts on biodiversity have been addressed in Section 7.3.3 and so this Section will focus on the potential human related noise impacts.

Severity

Noise pollution will have different impacts on different receptors because some are very sensitive to noise and others are not. For example, workers in general do not expect an environment free of work related noise and so they will be less sensitive to environmental noise pollution at work. In contrast, visitors to the Namib Naukluft Park are likely to be sensitive to unnatural noises and so any change to ambient noise levels because of mine related noise will have a negative impact on them and their wilderness experience. From observations in the field, the diesel generator(s) at the Swakop River boreholes emit noise pollution that will be heard by visitors in the surrounding area and visitors to Bloedkoppie will hear existing blasting noise and may hear noise from other LHU activities depending on the wind direction. The Bloedkoppie receptor site will experience ongoing and possibly even increased noise pollution during the operational phase because of the plan to mine in the eastern area of the ML, which is approximately 1km from Bloedkoppie.

In both the managed and unmanaged scenarios, it is estimated that because of the sensitivity of the receptors this noise will have a medium severity.

Duration

In both the unmanaged and managed scenarios the noise pollution impacts will be experienced by most visitors until the closure phase of the mine.

Spatial scale

In both the unmanaged and managed scenarios the noise impacts will extend beyond the ML.

Consequence

In both the unmanaged and managed scenarios the consequence is medium.

Probability

The probability of the noise impact occurring is high in both the managed and unmanaged scenario. Limited management options are available.

Significance

In the managed and unmanaged scenario, the significance of this potential impact is medium.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**M**	**M**	**M**	**M**	**H**	**M**
Managed	**M**	**M**	**M**	**M**	**H**	**M**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to limit excessive noise pollution.

Actions

All registered complaints will be documented, investigated and efforts made to address the area of concern where possible.

Where possible, the activities most likely to cause noise pollution impacts will be restricted to daytime activities.

Emergency situations

None identified.

7.9. ARCHAEOLOGY

The information in this section was sourced from the archaeology specialist study in Appendix K (Kinahan 2009).

7.9.1. ISSUE: DAMAGE TO ARCHAEOLOGICAL SITES AND LANDSCAPES

TABLE 7-14: DAMAGE TO ARCHAEOLOGICAL SITES – LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning – cumulative	Closure - cumulative
Infrastructure establishment Soil stripping Cleaning and grubbing Preparation of the foundations Compacting bases Opening borrow pits and trenches Slope stabilization Building roads Vehicle movement	Mining development Vehicle movement waste management (mineralised) stockpile development	Removal of infrastructure Vehicle movement Material movement Slope stabilization	N/A

Assessment of impact

Introduction

With reference to Table 7-14, there are a number of activities/infrastructure in all phases that have the potential to damage archaeological resources. Although the assessment considers both the unmanaged and managed scenarios, some of the specialists recommended management actions, including the additional field work and documentation of the archaeological sites, have already been implemented and are presented in Appendix K (Kinahan 2009).

Severity

With reference to the archaeological sensitivity map (Figure 3-14) the proposed new activities within the ML are mostly located in an area of less archaeological sensitivity relative to the rest of the existing approved activities and infrastructure within the ML. In contrast, parts of the proposed power line route to the Swakop River are situated near to sites associated with the historical battlefield which is considered relatively more sensitive.

The specialist study indicates that there will be a measurable archaeological loss because, even with management, some sites will be damaged and/or disturbed and the associated archaeological landscape will be negatively affected. In the unmanaged scenario this is a potential a high severity. With management, this is a medium severity because the sensitivity of the sites that will be disturbed is moderate to low and the relevant information has been gathered and documented.

Duration

In both the unmanaged and managed scenarios, the loss of archaeological sites and related losses to the broader archaeological landscape is long term and will continue after the life of the mine.

Spatial scale

In the managed scenario, the impacts will be localised within the ML. In the unmanaged scenario, the potential impacts may extend outside of the ML along the Swakop River power line route.

Consequence

The consequence of this potential impact is high in the unmanaged scenario. It reduces to medium in the managed scenario because the severity and spatial scale are reduced.

Probability

Even with management the impact is definite.

Significance

The significance of this potential impact is high in the unmanaged scenario and medium in the managed scenario.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**H**	**H**
Managed	**M**	**H**	**L**	**M**	**H**	**M**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to prevent the unacceptable loss of archaeological sites and related historical information.

Actions

In the construction, operation and decommissioning phases LHU will ensure that:

- it limits mine infrastructure, activities and related disturbance to those specifically identified and described in this EIA report;

- the proposed power line to the Swakop River will be positioned in a way that it does not disturb the battlefield sites, which will be cordoned off by means of a clearly visible warning sign and/or tape barriers during construction of the power line;
- where archaeological sites will be disturbed and/or destroyed the information in the specialist report will be used to apply for the necessary permits that are required in terms of the National Heritage Act 2004; and
- all workers (temporary and permanent) will be educated about the archaeological sites that may be encountered.

Emergency situations

If there are any chance finds of archaeological sites that have not been identified and described in the specialist report, LHU will follow its chance find procedure. The key component of which is to ensure that the site remains undisturbed until a specialist has assessed the site, assessed the potential damage, advised on the necessary management steps and advised on the requirements for stakeholder consultation and permitting.

7.10. VISUAL

The information in this section was sourced from the visual specialist study in Appendix L (NLA 2009).

7.10.1. ISSUE: VISUAL IMPACT

TABLE 7-15: VISUAL IMPACT – LINK TO MINE PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
Foundations Trenches Stockpiles Scaffolding Cranes Borrow pits Roads Power lines Pipelines	Open pits Stockpiles TSFs Water dams Voids Trenches Buildings and equipment Surface subsidence Pipelines Power lines	Open pits Stockpiles TSFs Water dams Voids Trenches Surface subsidence Scaffolding Cranes Piles of rubble Piles of scrap Pipelines Power lines	Permanent TSF Permanent water dams Permanent stockpiles Final voids (if any) Surface subsidence

Assessment of impact

Introduction

With reference to Table 7-15, visual impacts may be caused by activities and infrastructure in all mine phases.

Severity

The severity of visual impacts is determined by assessing the change to the visual landscape from mine related infrastructure and activities.

As discussed in Section 3.15, the visual landscape is determined by considering: landscape character, sense of place, aesthetic value, sensitivity of the visual resource and sensitive views. In this regard, the area in which LHU is situated is considered to have a significant visual landscape.

When considering the potential change to the visual landscape the key issues are: visual exposure, visual intrusion, and sensitivity of receptors. Each of these issues is discussed below.

Visual exposure is the extent to which mine infrastructure and activities will appear in the various views. It follows that the closer the infrastructure and activities, the greater the visual exposure. Views from Bloedkoppie and the Swakop River battlefields present the greatest visual exposure. Therefore, apart from the possible power line, the greatest visual exposure activities and infrastructure are those that are associated with the current approved LHU mine that will take place in the eastern part of the ML.

Visual intrusion is the extent to which the infrastructure and activities will contrast with the visual landscape and can/cannot be absorbed by the landscape. The visual intrusion of the proposed expansion project is considered to be medium, but taken cumulatively with the current infrastructure and activities, this intrusion is high. Of most concern is the visual intrusion of the mine when operations move to the east, closer to Bloedkoppie. In addition, the intrusion of night lighting may be significant, particularly in the unmanaged scenario.

Sensitivity of receptors relates to the way in which people will view the visual intrusion. In this regard, it is anticipated that receptors will be sensitive at Bloedkoppie and in the Swakop River battlefield area, particularly in the unmanaged scenario.

Given the above, the unmanaged severity is high. This can be reduced to medium in the managed scenario.

Duration

In the unmanaged scenario, the visual impact will be experienced after the life of mine. Depending on the effectiveness of the management actions, this may be reduced to the period before closure in the managed scenario.

Spatial scale

By using a viewshed analysis tool the specialist determined that larger LHU infrastructure will be highly visible at distances of up to 10km in an east west orientation. It follows that the spatial scale of the impacts will extend beyond the ML in the unmanaged scenario. With management, the visual intrusion may not be noticeable from sensitive viewing areas outside of the ML.

Consequence

In the unmanaged scenario the consequence is high. In the managed scenario, the consequence reduces to medium because the severity, spatial scale and duration can be reduced.

Probability

The probability of the visual impact occurring is high in unmanaged scenario and medium in the managed scenario.

Significance

In the unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance is reduced to between medium because the severity and duration are reduced.

Tabulated summary of the assessed cumulative impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**H**	**H**
Managed	**M**	**M**	**M**	**M**	**M**	**M**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to limit excessive visual impacts.

Actions

During construction, operation and decommissioning the following general principles apply:

- land disturbance will be limited to what is absolutely necessary;
- where possible, buildings and large equipment will be painted with colours that reflect natural colours of the surrounding landscape;
- in the shaping of any structures that will remain after closure, harsh, angular and steep slopes will be avoided and care should be taken to integrate these structures into the surrounding landscape;
- all dust plume sources will be managed with dust suppressants to limit visual intrusion by dust;
- night lights will be used only where necessary and should be design to illuminate only that which requires illumination. The use of standard high pole flood lights should be avoided;
- litter will be prevented;

- in consultation with relevant stakeholders, sections of the power line to the Swakop River may be routed underground in areas that are particularly sensitive to the visual landscape associated with the battlefield;
- subject to approval by MET Parks and Wildlife, the perceptions and sensitivity of the tourist viewers from Bloedkoppie will be managed by the placement of tourist information boards about the mine and its visible infrastructure.

Emergency situations

None identified.

7.11. SOCIO-ECONOMIC

The information in this section was sourced from the social and economic specialist studies in Appendix M (Hoadley 2009) and Appendix N (Metago Strategy4Good 2009).

In the broadest sense (see Table 7-16), the activities associated with LHU will have socio-economic impacts in all mine phases. Some of these are considered to be positive impacts and others are considered to be negative impacts. The separate groups of impacts are discussed below.

TABLE 7-16: SOCIO-ECONOMIC IMPACTS – LINK TO PROJECT PHASES

Construction for project	Operational -cumulative	Decommissioning - cumulative	Closure - cumulative
New construction activities	Existing and proposed operational activities	Decommissioning activities	Aftercare and maintenance activities

7.11.1. ISSUE: ECONOMIC IMPACT

Assessment of impact

Severity

The continued operation and expansion of LHU is predicted to have a positive impact on both the Erongo regional economy (approximately 20% contribution to gross geographical product) and the Namibian economy (approximately 4% contribution to the gross domestic product) in the following ways:

- related investment and investor confidence in the Namibian economy;
- foreign exchange income from the export of uranium product;
- increase in employment and household income. To add to the current employment levels of approximately 200 permanent employees and 200 long terms contractors, the proposed project will introduce approximately 90 permanent (employee and long term contractor) positions,
- increase in local economic development and procurement opportunities in mining related industries; and

- increase in the taxes that accrue to the Namibian government.

A potentially negative economic impact is on tourism. This stems from the possibility that the experience of tourists in the area around the mine may be compromised (by the various environmental impacts discussed in Section 7) to the point that tourists and operators choose not to visit this area to the same degree in future. This impact is one that may negatively impact both direct tourism employment in the Erongo region and tourism activity within the Namib Naukluft Park. It may also indirectly impact on various components of the associated hospitality sector (eg. accommodation, travel and food). In this regard, it must be noted that the significant increase in mining and business related activity in the Erongo region brings additional activity to the hospitality sector that may offset some potential tourism related impacts on accommodation, food and travel. It must also be noted that the potential impact on tourism is not specific to LHU but is a cumulative issue presented by a number of mining and prospecting operations in the region. The net potential impact is that a greater area of the Namib Naukluft Park is not frequented by tourists to the same degree as it would have been without the existence of the mines and related activities. These cumulative impacts are being assessed in a strategic environmental assessment for the region.

The view of the economic specialist is that the mining and tourism sectors can co-exist such that negative impacts on tourism are limited in the managed scenario.

As a cumulative issue, the economic benefits are predicted to outweigh the potential losses and therefore the positive severity is considered to be between moderate to substantial depending on the management of the impacts on the tourism sector.

Duration

In the normal course, the direct positive economic impacts associated with the mine will occur for the life of mine. After closure there may still be some positive impacts through maintenance and aftercare activities and because it is predicted that LHU would have contributed to a greater economic critical mass, skills, and wealth that can be used in other economic opportunities. Quantitatively assessing the post closure impacts is not possible because there are a number of important unknown factors such as the general state of the future economy (local, national and world wide) and the future state of the mining sector in particular.

The negative impacts on the tourism sector may continue post closure or they may be improved post closure depending on the success of the LHU rehabilitation and closure plan.

<u>Spatial scale</u>

In both the unmanaged and managed scenarios, the impact will be felt both in the Erongo region and in other economic centres of Namibia such as Windhoek. With additional management, it may be possible to retain more of the benefit in the regional economy.

<u>Consequence</u>

In the unmanaged scenario the consequence is medium. In the managed scenario, this increases to high because the positive severity of the impact is increased.

<u>Probability</u>

In the normal course of economic activity the net positive impacts will definitely occur. With management, the potential negative impacts on tourism and the potential to contribute to positive impacts post closure is improved. The issue of planning for post closure is also relevant to the unplanned scenario where the mine has to prematurely downscale or close.

<u>Significance</u>

In the unmanaged scenario, the significance of this potential impact is medium positive. In the managed scenario, the significance is further increased.

Tabulated summary of the assessed cumulative on-site impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**M+**	**M-H**	**H**	**M+**	**M-H**	**M+**
Managed	**H+**	**M-H**	**M-H**	**H+**	**H**	**H+**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

<u>Objective</u>

The objective of the management measures is to enhance the positive economic impacts and limit the negative economic impacts.

<u>Actions</u>

From the outset LHU will ensure that:

- it incorporates economic considerations into its closure planning;
- that these considerations cover the skilling of employees for the downscaling, early closure and long term closure scenarios; and
- that these considerations cover the needs of tourism for the downscaling, early closure and long term closure scenarios.

LHU will engage with relevant people and entities in the tourism sector to ensure that potential negative impacts from mining are managed in a way that the related impacts on tourism are acceptable. This engagement may be through new or existing collective structures and it will ideally also involve other mining and exploration companies that have the potential to negatively impact on tourism. The findings and recommendations of the strategic environmental assessment will be incorporated into these collective efforts.

In order to enhance the regional economic impacts, LHU will continue to consider ways to empower, support and use local/regional people for employment and local business for procurement. It will also consider other ways to enhance local economic development

Emergency situations

None identified.

7.11.2. ISSUE: ROAD USE AND TRAFFIC IMPACTS

For an understanding of the road network, this section should be read with reference to Figure 1-1, Figure 1-2 and Figure 3-9.

Assessment of impact

Mine related traffic travels to and from site (from Walvis Bay and Swakopmund in particular) on a daily basis. Ultimately, all traffic joins the C28 road from which the private mine access road branches off. Traffic on the private access road is mostly mine related. Traffic on the C28 and other feeder roads to the C28 (B2 and C34/D1984) is a combination of LHU, other mining, other business, private and tourism related traffic.

As quantified in Sections 6.1.2 and 6.2.7, the proposed project will cause a temporary increase in traffic volumes during the construction phase and a more long term increase during the operational phase. In construction this relates to the transport of workers and building materials and in the expanded operation this relates to increased workers, increased supplies and services, and increase product output. Traffic in the decommissioning phases will reduce to the extent that production related traffic ceases. Traffic in the post closure phase will be limited.

Given the above, the focus of this assessment is the cumulative construction and operational impacts on road users of the C28, and feeder points from the C34/D1984 and B2, but particularly on the C28. In this regard, the C28 is a road with some gravel and tarred sections (tarring was funded by LHU), the C34/D1984 is a salt road, and the B2 is a tarred road.

Severity

The social specialist has through anecdotal information noted that current road use and traffic related issues include the following:

- the C28 can present a safety risk to people who are not familiar with driving on gravel roads. The particular safety related issues are the dust that make visibility difficult and the gravel surface that can present a traction problem when vehicles drive quickly and/or attempt to pass other vehicles;
- uneven road surfaces causes significant vibration with knock on effects of higher vehicle maintenance and repair costs;
- loose gravel can lead to cracked windscreens;
- some road accidents, involving vehicles and animals, have occurred over the past few years; and
- maintenance of the C28 by the relevant roads authority does not keep pace with the wear and tear from current traffic levels.

Any increase in traffic from LHU and/or other sources has the potential to add to the abovementioned issues.

In the unmanaged and managed scenario, the potential for injury and death to road users gives this a high severity.

Duration

Any serious injury or death is a long term impact.

Spatial scale

The impacts will extend beyond the mine boundary.

Consequence

In both the unmanaged and managed scenarios the consequence is high.

Probability

In the unmanaged scenario, the potential impacts on road users will continue and possibly even increase. Depending on the effective implementation of the management measures, the probability can be significantly reduced. In this regard, the recommended management measures are not applicable to LHU in isolation and will require the co-operation of third parties.

Significance

In unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance is reduced to medium because the probability is reduced.

Tabulated summary of the assessed cumulative on-site impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**H**	**H**
Managed	**H**	**H**	**M**	**H**	**L**	**M**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

<u>Objective</u>

The objective of the management measures is to reduce the potential for safety and vehicle related impacts on road users.

<u>Actions</u>

Ensure basic road safety behaviour for all LHU employees through training and awareness. In addition, contracts between LHU and contractors will ensure that the contractors conform to the same behaviour as employees. Typical issues include:

- keeping to safe speed limits;
- ensuring that drivers all have valid licenses;
- making sure that all vehicles are roadworthy;
- zero tolerance for drinking and driving; and
- using lights appropriately for night driving.

An action that is not within the direct control of LHU, but that LHU will be part of, is a collective approach to road solutions in the region, and for the C28 in particular. In this regard, the relevant parties (LHU, other mines, the relevant road authority, tourist organisations, and other substantial road users) will investigate the possibility of monitoring and upgrading the C28 road further than it has already been.

<u>Emergency situations</u>

Any mine related road accident must be handled in accordance with the LHU emergency response procedure.

7.11.3. ISSUE: INWARD MIGRATION

Assessment of impact

<u>Severity</u>

There are a number of negative issues that can arise from inward migration of job seekers to urban areas (Walvis Bay and Swakopmund in particular) in the Erongo region. While it is not possible to establish a defendable direct causal link between the existing LHU mine or the proposed expansion, and the regional phenomena of inward migration, it is reasonable to assume that inward migration will occur both directly and/or indirectly from regional economic development in general, and that LHU is a significant part of this development.

With inward migration the following negative social issues arise:

- development of informal settlements;
- increase in crime;
- spread of diseases such as HIV/AIDS and tuberculosis and related deaths;

In the unmanaged scenario, the inward migration issue is predicted to have a cumulative high severity. In the managed scenario, the inward migration severity may reduce but the challenge is significant because it will involve a focussed and combined effort from the commercial and government sectors. More specific assessment of this issue is required as part of the regional strategic environmental assessment.

Duration

In the normal course, social impacts associated with the mine will occur for the life of mine. However, issues associated with inward migration take on a life of their own and are likely to extend long after the life of LHU. This applies in both the managed and unmanaged scenario.

Spatial scale

In both the unmanaged and managed scenarios, the impacts of inward migration will be felt mainly in the Erongo region.

Consequence

In the unmanaged scenarios the consequence associated with inward migration is high. This may reduce in the managed scenario if the severity is reduced through management interventions.

Probability

In the unmanaged scenario the impact is definite. In the managed scenario this probability may be reduced but the challenge is significant and it involves multiple parties.

Significance

In unmanaged scenario, the significance of this potential impact is high. In the managed scenario, the significance may be reduced.

Tabulated summary of the assessed cumulative inward migration impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**H**	**H**	**M**	**H**	**H**	**H**
Managed	**M-H**	**H**	**M**	**M-H**	**M-H**	**M- H**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to limit the impacts associated with inward migration.

Actions

LHU will collaborate with local and regional government and other entities in the commercial sector to identify and implement interventions that may assist with the prevention of inward migration and/or the prevention of the associated negative impacts. More specific recommendations are expected from the regional strategic environmental impact assessment. In this regard, LHU's involvement will be documented for record keeping purposes.

Emergency situations

None identified.

7.11.4. ISSUE: SOCIAL WELLBEING IMPACTS

Assessment of impact

Severity

The existence of the LHU mine (in its current or expanded form) as a standalone entity can directly and indirectly impact on people wellbeing (health and welfare) both in the workplace and in the context of worker families and communities. In this regard, there is a link between health and welfare issues at the community of the workplace and the community of the residential place. Related issues include: working conditions, health, education and training.

In the unmanaged scenario, the social wellbeing impacts are predicted by the specialist to have a cumulative medium negative severity. In the managed scenario, the severity can be reduced and possibly even turned into a positive.

Duration

In the unmanaged scenario, negative social wellbeing impacts may continue after mine closure. With management, the negative issues are likely to be restricted to the life of mine and/or they may become positive within the life of mine.

Spatial scale

In both the unmanaged and managed scenarios, the impacts will be felt in the workplace and in the communities that LHU workers reside in.

Consequence

The consequence in the unmanaged scenario is medium negative, but this can become a positive consequence with management.

Probability

The probability of the impacts occurring is considered to be medium in both the managed and unmanaged scenarios.

Significance

In unmanaged scenario, the significance of this potential impact is medium negative. In the managed scenario, the significance may at best be turned into a medium positive.

Tabulated summary of the assessed cumulative social disturbance issues (excluding inward migration)

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmanaged	**M**	**M-H**	**M**	**M**	**M**	**M**
Managed	**L- to L+**	**M**	**M**	**L- to L+**	**M**	**M- to M+**

Conceptual description of existing and proposed LHU management measures

Discussion of the management measures is provided below and in the EMP (Appendix Q).

Objective

The objective of the management measures is to reduce negative social wellbeing impacts and where possible, turn them into positives.

Actions

Specific actions include the following:

- implement a stakeholder communication and engagement strategy. The key components of which are: maintaining an inclusive comprehensive stakeholder database that recognises both internal and external stakeholders, encouraging meaningful and transparent communication and information sharing, ongoing monitoring to ensure that the strategy is up to date, and follow up auditing.

- develop a formal complaints (grievance) procedure that incorporates measures for receiving, responding, tracking and recording complaints and grievances from both internal and external stakeholders;
- maintain an employee profile that can assist with both managing social wellbeing impacts and informing the LHU closure plan – for both long term planned closure and for unplanned premature downscaling or closure;
- develop worker radiation, HIV/AIDS and tuberculosis programmes that can be extended to contractors and service providers, and into the LHU communities where LHU workers reside (interest communities);
- encourage formal home ownership and discourage informal housing for employees and contractors
- extend employee education programmes on social and health issues into interest communities

Emergency situations

None identified.

8. ENVIRONMENTAL IMPACT STATEMENT & CONCLUSION

From an incremental perspective, in the managed scenario, the potential negative impacts associated with the proposed expansion project are expected to be of low significance and therefore, provided that the relevant management measures are successfully implemented, there is no environmental reason why the expansion project should not be approved.

The cumulative assessment of the proposed expansion project and the existing approved activities and infrastructure presents the potential for more significant impacts (a tabulated summary of the cumulative impacts is presented in Table 8-1). Accordingly, LHU has committed to apply the findings of the cumulative assessment and related management objectives and actions to both the proposed and existing approved activities and infrastructure.

TABLE 8-1: TABULATED SUMMARY OF POTENTIAL CUMULATIVE IMPACTS

Section	Potential impact	Significance of the impact (the ratings are negative unless otherwise specified)	
		Unmanaged or partially managed	Managed
Topography	Injury to people and animals form hazardous excavations and infrastructure	**High**	**Medium-**
Soils	Loss of soil resources from pollution	**High-**	**Low-**
	Loss of soil resources from physical disturbance	**High-**	**Medium to high-**
Biodiversity	Physical destruction of biodiversity from clearing land and placing infrastructure	**High-**	**Medium to High-**
	Loss of biodiversity from the reduction of water resources as an ecological driver	**High-**	**Medium to High-**
	General disturbance of biodiversity through a range of aspects including dust, noise, vibration, pollution, lighting, poaching, and vehicle movement.	**High-**	**Low-**
Radiological – direct radiation	Direct physical exposure to radiation from on-site sources	**Medium to Low**	**Low**
Surface water	Pollution of surface water – radiological and non-radiological	**Medium-**	**Low-**
Groundwater	Water abstraction impacts on third party users	**Medium**	**Low-**
	Groundwater contamination– non radiological	**High-**	**Medium to Low-**
	Groundwater contamination– radiological and related secondary pathways	**High-**	**Medium to low-**
Air quality	Air pollution – non radiological	**High-**	**Medium-to low**
	Air pollution – radiological and related secondary pathways	**Medium to Low**	**Low**

Section	**Potential impact**	**Significance of the impact (the ratings are negative unless otherwise specified)**	
		Unmanaged or partially managed	**Managed**
Noise	Noise pollution in the context of sensitive receptors within the Namib Naukluft Park	**Medium-**	**Medium-**
Archaeology	Damage to archaeological sites and landscapes	**High-**	**Medium-**
Visual impacts	Visual impact from sensitive views within the Namib Naukluft Park	**High-**	**Medium-**
Socio-economic impacts	Cumulative economic impact including the positive impacts on regional and national economies and the potential negative regional impacts on tourism	**Medium+**	**High+**
	Road use and traffic impacts which include damage to vehicles and injury from accidents	**High-**	**Medium-**
	Inward migration of job seekers that may lead to poor living conditions, increased crime and accelerated spread of disease in urban areas.	**High-**	**Medium to High-**
	Social wellbeing impacts of LHU workers and related communities. Related issues include working conditions, health, education and training.	**Medium-**	**Medium – to Medium +**

Fiona Parkin
(Project Assistant)

Brandon Stobart (EAPSA)
(Project Manager)

Colleen Parkins (PrSci Nat)
(Reviewer)

Metago Environmental Engineers (Pty) Ltd

9. OTHER LEGISLATION AND POLICY FRAMEWORKS

Other Namibian legislation, international conventions and protocols, regional agreements, and best practice guidelines and standards have been listed in the EMP report (Appendix P) and have been integrated into Section 7 of the EIA report and into the specialist reports where relevant. Two issues are discussed in more detail below. These include the Equator Principles (2006) and health and safety.

Equator principles

The Equator Principles were compiled by representatives of various banks who identified the need to create a banking industry framework to address environmental and social issues in project financing. These principles are used as a benchmark for the financial industry to evaluate and manage the social and environmental impacts of projects financed through institutions which are Equator Principle signatories.

In addition to the Namibian EIA requirements as discussed in Section 1, LHU has requested that the EIA and EMP takes some of the high level environmental and social aspects of the Equator Principles into account. The Principles and related commentary are presented in Table 9-1.

TABLE 9-1: EQUATOR PRINCIPLES

High level description of Principles	Comment in relation to LHU
Equator Principle 1: Review and Categorisation	
All projects are categorised based on the magnitude of their potential environmental and social risks and impacts. Category A projects have potential significant adverse social or environmental impacts that are diverse, irreversible or unprecedented. Category B projects have limited adverse social or environmental impacts, which are site-specific and largely reversible, while Category C projects have minimal social or environmental impacts.	The LHU expansion project would be considered to be a Category A project.
Equator Principle 2: Social and Environmental Assessment	
A social and environmental impact assessment (SEIA) process, relevant to the nature and scale of the project, must be undertaken to address the potential social environmental risks and impacts of the project, incorporating specialist studies where necessary. The assessment is also required to propose relevant mitigation and management measures.	The EIA and EMP reports address most of the related issues as set out in Exhibit ii of Principle 2. Some aspects not covered in the EIA and EMP report are covered as part of ongoing environmental, health, safety and social management.
Equator Principle 3: Applicable Social and Environmental Standards	
For projects located in non-OECD* countries, the assessment will refer to the IFC** Performance Standards (1-8) and the applicable industry-specific Environment, Health and Safety Guidelines. The performance standards address Social and Environmental Assessment and Management Systems, Labour and Working Conditions, Pollution Prevention and Abatement, Community Health, Safety and Security, Land Acquisition and Involuntary Resettlement, Biodiversity Conservation and Sustainable Natural Resource Management, Indigenous Peoples and Cultural Heritage. The relevant EHS Guidelines include: General EHS Guidelines (environment, occupational health and safety, community health and safety, decommissioning and closure) and EHS Guidelines for Mining. The SEIA must also address compliance with relevant host	While the EIA and EMP cover many of the applicable aspects of these performance standards, some are covered through the existing on-site management systems and procedures and other aspects will still have to be implemented by LHU.

High level description of Principles	**Comment in relation to LHU**
country laws, regulations and permits that pertain to social and environmental matters.	
Equator Principle 4: Action Plan and Management System	
An action plan, the level of which must be appropriate to the nature and scale of the project, which describes and prioritises the actions needed to implement the mitigation measures, corrective action and monitoring measures necessary to manage the social and environmental risks and impacts identified in the SEIA must be compiled. A social and environmental management system must be established and maintained to implement the action plan and corrective actions required to comply with host country laws and regulations as well as the requirements of the IFC performance standards and guidelines.	The management recommendations in the EIA and the plans in the EMP will be integrated into the LHU environmental management system.
Equator Principle 5: Consultation and Disclosure	
Projects which may have a significant adverse impact on local communities are required to undertake a consultation process. The consultation process must ensure the community's free, prior and informed consultation, and it must be demonstrated that the project has adequately incorporated the community's concerns.	It is unlikely that a specific local community will suffer significant adverse impacts. Nonetheless, a comprehensive disclosure and consultation process was followed as part of the EIA process.
Equator Principle 6: Grievance Mechanism	
Consultation, disclosure and community engagement must continue through the construction and operational phases of a project. A grievance mechanism must be established as part of the management system in order to receive and facilitate the resolution of concerns and grievances raised by those affected by the project. The affected communities must be informed about the grievance mechanism process, which must address all concerns promptly and transparently, in a culturally appropriate manner, and must be accessible to all community members.	Recommendations in this regard have been included in the EIA and EMP.
Equator Principle 7: Independent Review	
Equator Principle compliance of the SEIA, action plan and public consultation process must be assessed by an independent social or environmental expert, who is not directly related to the borrower, on behalf of the lending institution	The EIA was performed by a team of independent consultants and the EIA report reviewed by independent experts.
Equator Principle 8: Covenants	
Covenants must be incorporated into the financing documentation whereby the borrower is committed to comply with relevant host country environmental legal requirements, comply with the action plan, to provide periodic reports as required by the financial institution to document compliance with the action plan and host country environmental and social laws, regulations and permits, and to decommission the facilities in accordance with an agreed decommissioning plan.	LHU is committed to achieving these covenants.
Equator Principle 9: Independent Monitoring and Reporting	
The project is required to appoint an independent environmental and/or social expert, or to retain qualified and experienced external experts to verify monitoring information which is reported to the financial institution.	This will be implemented by LHU.
Equator Principle 10	
Financial institutions which are signatories to the Equator Principles are required to report publically at least annually about their Equator Principle implementation processes and experience. The reports typically include, as a minimum, the number of EP transactions, project categorisation and the implementation process.	This principle is relevant to financial institutions (banks) which are signatories to the Equator Principles.

**Organisation for Economic Co-operation and Development*

***International Finance Corporation*

Health and Safety

Health and safety aspects of the current approved activities and the proposed expansion were not considered in any detail in the EIA, but LHU has implemented a formal health and safety management system. The main components of which are summarised below.

The objectives of the health and safety management system are to ensure:

- a healthy and safe work environment;
- safe systems of work;
- safe plant and equipment; and
- the availability of such information, instruction, and training as required to promote worker health and safety.

LHU will continue to ensure health and safety hazard control both by design and engineered controls, and by procedures that are relevant to the nature and scale of the LHU activities. This applies both to current approved activities and to the proposed expansion. It also incorporates aspects associated with mines in general and aspects specific to a uranium mine with related radiological risks.

Health and safety induction is a requirement for all employees and contractors. All visitors are also required to attend a site induction prior to accessing the mine site. Specific training sessions have been developed and are provided to employees requiring specific health and safety skill sets.

Health and safety audits are routinely scheduled. Ad hoc audits are done more frequently to follow up on concerns and/or non-compliances. Incident reporting and management augments the audits.

All hazardous chemicals used on site have readily available material safety datasheets. Chemicals will not be chosen for use unless they undergo health and safety reviews, consideration of alternatives, and identification of methods of hazard control. Chemical hazards training is an integral part of safety training and induction. Procedures are developed for the use and handling of all dangerous chemicals. Correct personal protective equipment is supplied.

10. REFERENCES

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South African Water Quality Guidelines, Department of Water Affairs and Forestry, volume 8 (first edition), 1996.

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Visual assessment for the proposed expansion at LHU Mine, Newtown Landscape Architects, 2009.

APPENDIX A: INFORMATION-SHARING WITH AUTHORITIES

- Formal EIA notification letter including minutes of initial meeting with MET held on 03 February 2009.
- Environmental Contract between LHU and government

APPENDIX B: PUBLIC INVOLVEMENT DATABASE

APPENDIX C: INFORMATION SHARING WITH IAPS

- Background information document (BID).
- Newspaper advertisements placed in: The Namibian (25 February 2009), the Namib Times (24 February 2009) and The Republikein (26 February 2009).
- Site notices displayed in project area on 02 March 2009: Site notice in English and photographs of where site notices were placed.
- Minutes of scoping meeting held at the Hotel Safari in Windhoek on 10 March 2009.
- Minutes of scoping meeting held at the Pelican Bay Hotel on 11 March 2009.
- Minutes of scoping meeting held at the Rossmund Golf Course on 12 March 2009.
- Any follow up correspondence received before compilation of the EIA.
- The scoping report summary letter which includes the terms of reference as identified in scoping.
- Review comments on the EIA and EMP

APPENDIX D: SUMMARY OF ISSUES RAISED BY AUTHORITIES AND IAPS

APPENDIX E: CURRICULUM VITAE

APPENDIX F: SURFACE WATER STUDY

APPENDIX G: AIR STUDY

APPENDIX H: SOIL AND LAND CAPABILITY STUDY

APPENDIX I: BIODIVERSITY STUDIES

- Vegetation
- Vertebrates
- Invertebrates

APPENDIX J: GROUNDWATER STUDY

APPENDIX K: ARCHAEOLOGY STUDY

APPENDIX L: VISUAL STUDY

APPENDIX M: SOCIAL STUDY

APPENDIX N: ECONOMIC STUDY

APPENDIX O: RADIOLOGICAL STUDY

APPENDIX P: TAILINGS STUDY

APPENDIX Q: ENVIRONMENTAL MANAGEMENT PLAN

Metago Environmental Engineers (Pty) Ltd

Consulting Engineers and Scientists

RECORD OF REPORT DISTRIBUTION

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