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

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

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

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

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>
<thead>
<tr>
<th>Draft EIA Regulation requirement</th>
<th>Policy requirements</th>
<th>Reference in the EIA report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details of the environmental assessment practitioner (EAP) that compiled the report and the expertise of the EAP to carry out the EIA.</td>
<td>List of compilers.</td>
<td>Section 1.2.2.</td>
</tr>
<tr>
<td>Description of the property on which the activity is to be undertaken and the location of the activity on that property.</td>
<td>The affected environment.</td>
<td>Section 3 and 4, and Figure 6-1.</td>
</tr>
<tr>
<td>Description of the environment that may be affected by the activity.</td>
<td></td>
<td>Section 3 and 4.</td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td>Section 5.</td>
</tr>
<tr>
<td>Description and comparative assessment of alternatives identified during the EIA.</td>
<td></td>
<td>Section 5.</td>
</tr>
<tr>
<td>Indication of the methodology used in determining the significance of the potential environmental impacts.</td>
<td></td>
<td>Section 7.</td>
</tr>
<tr>
<td>Description of the manner in which the physical, biological, social, economic and cultural aspects of the environment may be affected by the proposed activity.</td>
<td></td>
<td>Section 7.</td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td>Section 7.</td>
</tr>
<tr>
<td>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.</td>
<td>The assessment and evaluation.</td>
<td>Section 7.</td>
</tr>
<tr>
<td>List of persons, organisations and organs of state that were registered as interested and affected parties (IAPs).</td>
<td></td>
<td>Section 2 and Appendix B.</td>
</tr>
<tr>
<td>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</td>
<td></td>
<td>Appendix D.</td>
</tr>
<tr>
<td>Draft EIA Regulation requirement</td>
<td>Policy requirements</td>
<td>Reference in the EIA report</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Copies of any representations, objections and comments received from IAPs.</td>
<td></td>
<td>Appendix C</td>
</tr>
<tr>
<td>Summary of the findings and recommendations of any specialist report</td>
<td></td>
<td>Section 7. Also see specialist reports attached between Appendix F and Appendix P.</td>
</tr>
<tr>
<td>Description of any assumptions, uncertainties and knowledge gaps</td>
<td>Assumptions and limitations. Complete or unavailable information.</td>
<td>Integrated into various sections of the report. Also see specialist reports attached between Appendix F and Appendix P.</td>
</tr>
<tr>
<td>An opinion on whether the activity must be authorised and related conditions</td>
<td>Conclusion and recommendations.</td>
<td>Section 8.</td>
</tr>
<tr>
<td>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</td>
<td></td>
<td>Section 5.2 and Section 8.</td>
</tr>
<tr>
<td>A draft environmental management plan (EMP)</td>
<td>Management plan Monitoring programme Audit proposal.</td>
<td>Appendix Q.</td>
</tr>
<tr>
<td>Financial guarantee as security for cost of rehabilitation, decommissioning or reclamation</td>
<td></td>
<td>Financial provision is managed internally by LHU on the company balance sheet.</td>
</tr>
<tr>
<td>Copies of specialist reports</td>
<td></td>
<td>Attached between Appendix F and Appendix P.</td>
</tr>
<tr>
<td>Other information required by the competent authority</td>
<td></td>
<td>Not applicable</td>
</tr>
<tr>
<td>Executive summary, Contents page, Introduction.</td>
<td></td>
<td>See EIA report before this table.</td>
</tr>
<tr>
<td>Terms of reference.</td>
<td>Appendix C</td>
<td></td>
</tr>
<tr>
<td>Approach to study.</td>
<td>Section 1.2.1</td>
<td>Sections 1 and 9</td>
</tr>
<tr>
<td>Administrative, legal and Policy requirements.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental contract.</td>
<td>Appendix A</td>
<td></td>
</tr>
<tr>
<td>Definitions of technical terms.</td>
<td></td>
<td>Integrated into various sections of the EIA report and included in the various specialist reports</td>
</tr>
<tr>
<td>Acknowledgements.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendices.</td>
<td>Attached.</td>
<td></td>
</tr>
</tbody>
</table>
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**

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

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**

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

<table>
<thead>
<tr>
<th>Title</th>
<th>Environmental specialist</th>
<th>General manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Mr Werner Petrick</td>
<td>Mr Wyatt Buck</td>
</tr>
<tr>
<td>Postal address</td>
<td>PO Box 156 Swakopmund Namibia</td>
<td>PO Box 156 Swakopmund Namibia</td>
</tr>
<tr>
<td>Telephone number</td>
<td>+264 644106238</td>
<td>+264 64410 6201</td>
</tr>
<tr>
<td>Facsimile number</td>
<td>+264 644106299</td>
<td>+264 64410 6299</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>TASK</th>
<th>DESCRIPTION</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notification - regulatory authorities and IAPs</td>
<td>A pre-notification meeting was held with the MET. Minutes of the meeting are included in Appendix A.</td>
<td>03 February 2009</td>
</tr>
<tr>
<td>Pre-notification meeting with MET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Written notification to MET</td>
<td>Formal written notification was submitted to the MET. A copy of the notification letter is attached in Appendix A.</td>
<td>24 February 2009</td>
</tr>
<tr>
<td>IAP identification</td>
<td>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.</td>
<td>February 2009</td>
</tr>
<tr>
<td>TASK</td>
<td>DESCRIPTION</td>
<td>DATE</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Distribution of background information document (BID)</td>
<td>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.</td>
<td>February – March 2009</td>
</tr>
<tr>
<td>Site notices</td>
<td>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.</td>
<td>February 2009</td>
</tr>
<tr>
<td>Newspaper advertisements</td>
<td>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.</td>
<td>February 2009</td>
</tr>
<tr>
<td>Scoping stage meetings and submission of comments</td>
<td>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.</td>
<td>10 – 12 March 2009</td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Review of scoping report</td>
<td>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.</td>
<td>From 16 April 2009</td>
</tr>
<tr>
<td>IAPs and authorities (excluding MET) review of scoping report</td>
<td>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.</td>
<td>May to June 2009</td>
</tr>
<tr>
<td>MET review of scoping report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TASK</td>
<td>DESCRIPTION</td>
<td>DATE</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td><strong>Review of EIA and EMP reports</strong></td>
<td>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.</td>
<td>August to September 2009</td>
</tr>
<tr>
<td><strong>Public open days</strong></td>
<td>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.</td>
<td>September 2009</td>
</tr>
<tr>
<td><strong>MET review of EIA and EMP report</strong></td>
<td>A copy of the final EIA and EMP report, including all review comments, will be forwarded to MET for decision.</td>
<td>October 2009</td>
</tr>
</tbody>
</table>

### 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, occurring 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 highest in a central core zone with uranium distribution totally irregular and discontinuous.

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**

<table>
<thead>
<tr>
<th>Layers</th>
<th>Geology</th>
<th>Hydraulic Properties</th>
<th>Original state and properties</th>
<th>Interpretation for groundwater model</th>
<th>Layer Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 1</td>
<td>Quaternary sediments</td>
<td>Unconfined</td>
<td>Recent channel, sediments, dry</td>
<td>Can be rewetted by floods, perched water table, drainage on the surface of layer L2a, percolation into the unsaturated layer L2a.</td>
<td>Up to 8m thick</td>
</tr>
<tr>
<td>Layer 2a</td>
<td>Tertiary sediments, calcrite</td>
<td>Partially and temporarily confining layer</td>
<td>Dry, confines 3rd layer</td>
<td>Layer 2a - Partially kartified.</td>
<td>Up to 14m thick</td>
</tr>
<tr>
<td>Layers</td>
<td>Geology</td>
<td>Hydraulic Properties</td>
<td>Original state and properties</td>
<td>Interpretation for groundwater model</td>
<td>Layer Thickness</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------</td>
<td>-----------------------</td>
<td>------------------------------</td>
<td>-------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Layer 2b</td>
<td>and/or clay</td>
<td></td>
<td></td>
<td>Layer 2b - Less permeable sublayer, can be rewetted.</td>
<td>Up to 20m thick</td>
</tr>
<tr>
<td>Layer 3</td>
<td>Tertiary sediments, gravel with clay</td>
<td>Partially confined layer</td>
<td>Fully saturated, confined flow</td>
<td>Saturated, recharged by basement and by percolation depending on pressure gradients.</td>
<td>Up to 44m thick</td>
</tr>
<tr>
<td>Layer 4</td>
<td>Basement rock</td>
<td>Mainly low hydraulic conductivity</td>
<td>Inactive</td>
<td>Active recharge on basin, interacting with layer L3.</td>
<td>Greater than 150m in thickness</td>
</tr>
</tbody>
</table>

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
Average Period, Day-time and Night-time Windroses
Langer Heinrich (2006-2008)

Wind Speed Avg (m/s) @ 10 m
00:00-00 2006/01/01 - 23:00:00 2008/12/31

PERIOD

DAY-TIME

NIGHT-TIME

Average speed wind categories (m/s)

<table>
<thead>
<tr>
<th>Category</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Pink</td>
</tr>
<tr>
<td>1</td>
<td>Red</td>
</tr>
<tr>
<td>2</td>
<td>Orange</td>
</tr>
<tr>
<td>3</td>
<td>Yellow</td>
</tr>
<tr>
<td>4</td>
<td>Green</td>
</tr>
<tr>
<td>5</td>
<td>Light Blue</td>
</tr>
<tr>
<td>6</td>
<td>Medium Blue</td>
</tr>
<tr>
<td>7</td>
<td>Dark Blue</td>
</tr>
</tbody>
</table>

Circle Scale .... 5 %
100.0 %
Circle Centre Category: all below 1 - 2

SOURCES FROM THE AIR QUALITY STUDY UNDERTAKEN FOR THE PROJECT

LANGER HEINRICH URANIUM MINE
AVERAGE DAY AND NIGHT WIND ROSES

07/2009
L016-01
FIGURE 3-3: SEASONAL WIND ROSES
SEASONAL WIND ROSES FOR LANGER HEINRICH URANIUM MINE (2006-2008)

Wind Speed Avg (m/s) @ 10 m
00:00:00 2006/01/01 - 23:00:00 2008/12/31

Wind speed categories (m/s)
- 8 -
- 6 - 8
- 4.5 - 6
- 3 - 4.5
- 2 - 3
- 1 - 2

Circle Centre Category: all below 1 - 2

Circle Scale . . . . 5 %
100.0 %

SOURCED FROM THE AIR QUALITY STUDY UNDERTAKEN FOR THE PROJECT

LANGER HEINRICH URANIUM MINE
SEASONAL WIND ROSES

FIGURE 3.3
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.

Mountainous/rocky outcrop soils

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.

River system/alluvial soils

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
CLIENT: Metago Environmental Engineers (Pty) Ltd.

PROJECT: Langer Heinrich Uranium Mine

FIGURE: Combined Soil Mapping (WEST)

Legend
- Alluvials
- Colluvials
- Rocky outcrop
- Shallow plains
- Infrastructure

LANGER HEINRICH URANIUM MINE
SOILS IN THE WESTERN PART OF THE ML

07/2009

FIGURE 3.4
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
Plan showing the distribution of Vegetation Communities on ML 140 and EPL 3500

Data Source:
Vegetation Communities based on report: Phase 2 - Biodiversity description of the ML 140 and EPL 3500 as baseline for future planning, June 2009, by Marianne Stobbs.
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**

<table>
<thead>
<tr>
<th>Community number 1.1: <em>Commiphora virgata</em> – <em>Zygophyllum cylindrifolium</em> sparse shrublands on quartzite slopes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td>The most significant species found here is <em>Aloe namibensis</em> (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 <em>Commiphora glaucescens</em> (blue-leaved Commiphora), <em>Commiphora virgata</em> (slender Corkwood), and occasional specimens of <em>Sterculia africana</em> (tick tree), all shrubs with swollen, fibrous stems that can store water.</td>
</tr>
<tr>
<td>Other shrubs include <em>Boscia loetida</em> (Noeniebos) and <em>Euphorbia guerichiana</em> (paper-bark Euphorbia). A fair amount of nutritious grasses such as <em>Antephora pubescens</em> (wool grass), <em>Eragrostis nindensis</em> (eight-day love grass), <em>Stipagrostis uniplumis</em> (common bushman grass) and <em>Stipagrostis ciliata</em> (tall bushman grass) can be found on the slopes. Also conspicuous is the high diversity of sub-shrubs, most conspicuous are <em>Aptosimum lineare</em>, <em>Monechma cleomoides</em> (Namib perdebos), <em>Hermannia helianthemum</em> (rock Hermannia), <em>Petalidium variabile</em> (variable Petalidium), <em>Tephrosia monophylla</em> (single-leaved Tephrosia), <em>Barleria lancifolia</em> (blue Barleria) and <em>Zygophyllum cylindrifolium</em>. Scattered plants of <em>Euphorbia virosa</em> (candelabra Euphorbia), <em>Zygophyllum stapffii</em> (dollar bush), <em>Helichrysum tomentosulum</em> (aromatic Helichrysum), <em>Helichrysum roseo-niveum</em> (Namib Edelweiss) and <em>Sesamum marlothii</em> (Marloth’s sesame) are commonly encountered.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td><strong>Community statistics:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Irreplaceable community habitat.</td>
</tr>
<tr>
<td><strong>Management implications:</strong> This community and habitat should be disturbed as little as possible. The relatively high incidence of the red-listed <em>Aloe namibensis</em>, as well as the high number of observed and expected species indicates that this area should, as far as possible, be conserved.</td>
</tr>
</tbody>
</table>

**TABLE 3-3: VEGETATION COMMUNITY ASSOCIATED WITH GRANITES**

<table>
<thead>
<tr>
<th>Community number 1.2 <em>Petalidium variabile</em> – <em>Aloe dichotoma</em> sparse shrublands on granites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td>The variable Petalidium (<em>Petalidium variabile</em>) is a very constant species here, while the sporadic occurrence of <em>Aloe dichotoma</em> (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.</td>
</tr>
</tbody>
</table>
| 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 microcaris*. *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 Aptsimum angustifolium (Namib Aptsimum) 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

<table>
<thead>
<tr>
<th>Community number 1.3 Sterculia africana – Enneapogon sparse shrublands in quartzite ravines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td>The rock fig is located here, <em>Ficus cordata</em>, which will not be able to establish in any other habitat in the desert, as well as delicate herbs such as <em>Jamesbrittenia</em> species, and the sub-shrubs <em>Abutilon pycnodon</em> (desert Lantern flower), <em>Camptoloma rotundifolium</em>, <em>Amphiasma divaricatum</em>, <em>Anticharis imbricata</em> (rock Anticharis), <em>Barleria merxmuelleri</em> (spiny-cushion Barleria) and <em>Dyerothymum africanum</em> (desert statice). Further characteristic low trees are <em>Sterculia africana</em> (tick tree) and <em>Commiphora glaucescens</em> (blue-leaved Commiphora). Palatable perennial grasses found here are <em>Antephora pubescens</em> (wool grass) and <em>Enneapogon scoparius</em> (bottle-brush grass). The trailing <em>Cucumella aspera</em> is common on the steep slopes on the edge of the ravines, and occasionally large shrubs of the aromatic <em>Salvia garipensis</em> and <em>Helichrysum tomentosulum</em> (aromatic Helichrysum) can be found.</td>
</tr>
<tr>
<td>The number of species will vary significantly during years, as annual species and the sub-shrubs may disappear during prolonged dry periods.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>Sensitivity: Irreplaceable community and habitat</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

---

TABLE 3-5: VEGETATION COMMUNITY ASSOCIATED WITH BOULDER WASHES

<table>
<thead>
<tr>
<th>Community number 1.4 Petalidium variabile – Stipagrostis hochstetteriana sparse shrublands in boulder washes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td>The vegetation is characterised by a high but variable density of high shrubs such as <em>Calicorema capitata</em> (grey</td>
</tr>
</tbody>
</table>
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 lanceolata* (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.

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**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**

<table>
<thead>
<tr>
<th>Community number 2.1 <em>Eragrostis nindensis – Trianthema triquetra</em> sparse grasslands on conglomerates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td>The relative harshness of the abiotic environment is reflected in the almost absent shrubby vegetation, represented mostly by <em>Salsola tuberculata</em> (Gannabos) and <em>Calicorema capitata</em> (grey desert-brush), whilst <em>Commiphora</em> species occur along the upper edges of runoff channels.</td>
</tr>
<tr>
<td><em>Stipagrostis</em> species form the dominant layer, but these may disappear during unfavourable seasons. An important species remaining is <em>Eragrostis nindensis</em> (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.</td>
</tr>
<tr>
<td>Further species indicative on these plains are <em>Trianthema triquetra</em>, <em>Enneapogon desvauxii</em> (eight-day grass) and <em>Zygophyllum simplex</em>.</td>
</tr>
<tr>
<td><strong>Community statistics:</strong> 1 restricted endemics, 7 narrow endemics, 3 widespread endemics, 1 protected species, 2 keystone species, 50 observed species, 63 expected species</td>
</tr>
</tbody>
</table>
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 logs 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 northeastern 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 triqueta* 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.

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**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* 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.

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**Zygophyllum stapfii – Sesamum marlothii association**

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

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

Community number 3.1  

**Zygophyllum stapfii – Sesamum marlothii** riverine shrublands in narrow schist washes

**Description:** Relatively narrow flood channels between steeper schist outcrops and mountains, with schist gravel

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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-shrubs 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 endemcs, 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.

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**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 damarense** 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 damarense*, 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 damarenisis* 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

<table>
<thead>
<tr>
<th>Community number 4.2 <em>Acacia erioloba – Stipagrostis ciliata</em> sparse shrublands with low trees on river terraces</th>
</tr>
</thead>
</table>
| **Description:** Sandy or gravelly 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 gravelly 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 stapfii (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), *Herrmannia 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

<table>
<thead>
<tr>
<th>Community number 4.3 <em>Adenolobus pechuelii – Stipagrostis ciliata</em> sparse shrublands with low trees in shallow washes</th>
</tr>
</thead>
</table>
| **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

<table>
<thead>
<tr>
<th>Community number 5.1 Aizoanthemum rehmannii – Monechma desertorum sparse grasslands on gravel plains</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>Annual herbs that are commonly encountered, albeit in greatly varying densities, are Aizoanthemum rehmannii, Sesuvium sesuvioides (desert pink), Monechma desertorum, Lotiononis schreiberi, Kohautia caespitosa (desert perfume – scent is released at dusk), Zygophyllum simplex and Euphorbia phylloclada.</td>
</tr>
<tr>
<td>During dry years these low footslopes and plains may remain bare.</td>
</tr>
<tr>
<td>Community statistics: 1 restricted endemic, 6 narrow endemics, 4 widespread endemics, 1 keystone species, 59 observed species, 76 expected species.</td>
</tr>
<tr>
<td>Sensitivity: Least sensitive community and habitat.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>
TABLE 3-15: VEGETATION COMMUNITY ASSOCIATED WITH QUARTZ GRAVEL PLAINS

<table>
<thead>
<tr>
<th>Community number</th>
<th>5.2 Salsola tuberculata – Jamesbrittenia barbata sparse grasslands on quartz gravel plains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Plains with light-coloured, somewhat rounded quartz pebbles on top of a layer of very fine sand, possibly overlying a calcite crust are the habitat of this community. These plains occur mostly west of the ML, into the EPL, northwards 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 <em>Stipagrostis ciliata</em> (tall bushman grass), <em>Calicorema capitata</em> (grey desert-brush) and <em>Gomphocarpus filiformis</em>. Most of the species present here, including <em>Cleome paxii</em>, <em>Triraphis pumilio</em>, <em>Enneapogon desvauxii</em> (eight-day grass), <em>Aristida parvula</em>, <em>Stipagrostis subacaulis</em>, <em>Sporobolus nebulosus</em>, <em>Polygala pallida</em>, <em>Zygophyllum simplex</em> and <em>Aptosimum lineare</em> are below 15 cm tall. The low shrubs <em>Jamesbrittenia barbata</em> and <em>Salsola tuberculata</em> are usually also not higher than 30 cm. 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.</td>
</tr>
<tr>
<td>Community statistics:</td>
<td>2 restricted endemics, 7 narrow endemics, 2 widespread endemics, 1 keystone species, 40 observed species, 46 expected species.</td>
</tr>
<tr>
<td>Sensitivity:</td>
<td>Least sensitive community and habitat.</td>
</tr>
<tr>
<td>Management implications:</td>
<td>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.</td>
</tr>
</tbody>
</table>

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
Map showing the water pipeline route divided into sections to facilitate the vegetation impact assessment.

Source: Vegetation Study Undertaken for the Project

07/2009

FIGURE 3.8
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 ciliata* 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 below. 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 stapfii*), 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 stapfii 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, Salvadoria 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**

<table>
<thead>
<tr>
<th>Habitat 1 - Gawib River, tree-lined channel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> A wide flat-bottomed wash, characterised by the presence of numbers of large trees, particularly <em>Acacia erioloba</em> (camel thorn). The substrate is sandy. Besides trees, the vegetation also consists of perennial grass.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence elsewhere in the Central Namib:</strong> 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.</td>
</tr>
<tr>
<td><strong>Trophic guilds:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Highly sensitive community and habitat.</td>
</tr>
<tr>
<td><strong>Invertebrate habitat determinants:</strong> 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-dependent 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.</td>
</tr>
<tr>
<td><strong>Key ecological drivers:</strong> 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.</td>
</tr>
<tr>
<td><strong>Vulnerabilities and threats:</strong> 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.</td>
</tr>
</tbody>
</table>
FIGURE 3-10: INVERTEBRATE HABITATS IN THE ML
Invertebrate Habitat Plan of the LHU ML 140

Data Source:
Invertebrate Habitats based on specialist report; Phase II Invertebrate study of Langer Heinrich Uranium Mining Licence Area (ML 140), June 2009. Spot Image, Date 03.04.2009.

Scale:
2,000 1,000 0 2,000
Meters

Title:
Invertebrate Habitat Plan of the LHU ML 140

Date:
June 2009

Drawn:
The Maproom

LANGER HEINRICH URANIUM MINE
INVERTEBRATE HABITATS IN THE ML

FIGURE 3.10
07/2009
L016-01
TABLE 3-17: INVERTEBRATE HABITAT – GAWIB VALLEY, SANDY GRASS PLAINS

<table>
<thead>
<tr>
<th>Habitat 2 - Gawib valley, sandy grass plains</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence elsewhere in the Central Namib:</strong> Sandy grass plains are widespread in the eastern parts of the Central Namib.</td>
</tr>
<tr>
<td><strong>Trophic guilds:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Sensitive community and habitat.</td>
</tr>
<tr>
<td><strong>Invertebrate habitat determinants:</strong> 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.</td>
</tr>
<tr>
<td><strong>Key ecological drivers:</strong> 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.</td>
</tr>
<tr>
<td><strong>Vulnerabilities and threats:</strong> 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.</td>
</tr>
</tbody>
</table>

TABLE 3-18: INVERTEBRATE HABITAT – SCHIST HILLS

<table>
<thead>
<tr>
<th>Habitat 3 - Schist Hills</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> This habitat forms the sides of the Gawib valley in the central south, and northeast of the ML, with isolated outcrops scattered elsewhere.</td>
</tr>
<tr>
<td><strong>Occurrence elsewhere in the Central Namib:</strong> 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.</td>
</tr>
<tr>
<td><strong>Trophic guilds:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Least sensitive community and habitat.</td>
</tr>
</tbody>
</table>
| **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 wind-blown 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.

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**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 collateralistically 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 grass.
**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 (*Crypsicerus 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 aerolian 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:**

**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.

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**TABLE 3-25: INVERTEBRATE HABITAT – EPHEMERAL AQUATIC SYSTEMS**

<table>
<thead>
<tr>
<th>Habitat 10 - Cross cutting habitat – Ephemeral aquatic systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence elsewhere in the Central Namib:</strong> Will occur wherever and whenever sufficient rain falls, and the underlying substrate supports the existence of open surface water.</td>
</tr>
<tr>
<td><strong>Trophic guilds:</strong> limited aquatic herbivores, seasonal detritus feeders, scavengers, predators.</td>
</tr>
<tr>
<td><strong>Invertebrate habitat determinants:</strong> The presence of open water is the absolute determinant for this habitat, and</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Habitat 1 - Gawib valley floor</th>
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<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> It stretches along the length of the ML from the gravel plain in the west to the granite koppie in the east.</td>
</tr>
<tr>
<td><strong>Vertebrate groups:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Sensitive community and habitat.</td>
</tr>
<tr>
<td><strong>Vertebrate habitat determinants:</strong> 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.</td>
</tr>
<tr>
<td><strong>Threats and restoration:</strong> Much of the Gawib valley floor could be damaged. Initial rehabilitation will be relatively straightforward, 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).</td>
</tr>
</tbody>
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TABLE 3-27: VERTEBRATE HABITAT – GAWIB CHANNEL ACACIA FOREST

<table>
<thead>
<tr>
<th>Habitat 2 - Gawib channel acacia forest</th>
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<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> 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.</td>
</tr>
<tr>
<td><strong>Vertebrate groups:</strong> This habitat has the highest number of species of mammals (23), reptiles (21) and birds. It is likely that not all species were recorded.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Highly sensitive community and habitat.</td>
</tr>
<tr>
<td><strong>Vertebrate habitat determinants:</strong> 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.</td>
</tr>
<tr>
<td><strong>Threats and restoration:</strong> 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.</td>
</tr>
</tbody>
</table>
TABLE 3-28: VERTEBRATE HABITAT – UPPER GAWIB RIVER

<table>
<thead>
<tr>
<th>Habitat 3 - Upper Gawib River</th>
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<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> 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.</td>
</tr>
<tr>
<td><strong>Vertebrate groups:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Sensitive community and habitat.</td>
</tr>
<tr>
<td><strong>Vertebrate habitat determinants:</strong> 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.</td>
</tr>
<tr>
<td><strong>Threats and restoration:</strong> 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.</td>
</tr>
</tbody>
</table>

TABLE 3-29: VERTEBRATE HABITAT – LOWER GAWIB RIVER

<table>
<thead>
<tr>
<th>Habitat 4 - Lower Gawib River</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Its bed forms an unbroken connection of coarse sandy substrate, shrubs and trees from LHU to the Swakop River.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> 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.</td>
</tr>
<tr>
<td><strong>Vertebrate groups:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Highly sensitive community and habitat.</td>
</tr>
<tr>
<td><strong>Vertebrate habitat determinants:</strong> Vertebrates that would be more typical of the Swakop riverbed can use this relatively sheltered corridor to get from the Swakop River to LHU.</td>
</tr>
<tr>
<td><strong>Threats and restoration:</strong> 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 Acaia is restored.</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Habitat 5 – Gawib Tributaries coming from Langer Heinrich mountains</th>
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<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> The five prominent washes that drain the ML stretch into the Gawib Channel Acaia along the boundaries of the foothills quartzite bank and conglomerate.</td>
</tr>
<tr>
<td><strong>Vertebrate groups:</strong> 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.</td>
</tr>
</tbody>
</table>
**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.

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**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.

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**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 northwest 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 suricates, 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 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 determinants:** 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

<table>
<thead>
<tr>
<th>Habitat 10 - Schieferberg slope</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> The slopes projects into the ML and flanks the Shieferberg and Gawib Tributary</td>
</tr>
<tr>
<td><strong>Vertebrate groups:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Ranges from a least sensitive to irreplaceable community and habitat.</td>
</tr>
<tr>
<td><strong>Vertebrate habitat determinants:</strong> 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.</td>
</tr>
<tr>
<td><strong>Threat and restoration:</strong> 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 these 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.</td>
</tr>
</tbody>
</table>

TABLE 3-36: VERTEBRATE HABITAT – LANGER HEINRICH MOUNTAIN

<table>
<thead>
<tr>
<th>Habitat 11 - Langer Heinrich Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> The mountain itself falls outside the ML, but some of its foothills and water courses occur either inside, or along the northern border.</td>
</tr>
<tr>
<td><strong>Occurrence in ML:</strong> 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.</td>
</tr>
<tr>
<td><strong>Vertebrate groups:</strong> 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.</td>
</tr>
<tr>
<td><strong>Sensitivity:</strong> Irreplaceable community and habitat.</td>
</tr>
<tr>
<td><strong>Vertebrate habitat determinants:</strong> 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.</td>
</tr>
<tr>
<td><strong>Threats and restoration:</strong> 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.</td>
</tr>
</tbody>
</table>

TABLE 3-37: VERTEBRATE HABITAT – TINKAS MOUNTAIN

<table>
<thead>
<tr>
<th>Habitat 12 – Tinkas Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> 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.</td>
</tr>
</tbody>
</table>
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 km², 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 kopjes 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 kopjes 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 2,500,000 m$^3$ 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 calcrite 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
Langer Heinrich Uranium
- Groundwater Flow Model -

Environmental Impact Assessment
"Specialist Input"
Bittner Water Consult (Namibia) &
Institute of Hydrology (Freiburg/Germany)

LEGEND

- No-flow boundary
- Hydraulic heads [m, a. m. s. l.]
- Gawib river and tributaries

Flow direction

Paleochannel flow

LANGER HEINRICH URANIUM MINE
GROUNDWATER FLOW DIRECTION IN THE PALEO-CHANNEL AQUIFER

FIGURE 3.12
07/2009
L016-01
FIGURE 3-13: GROUNDWATER FLOW DIRECTION IN THE BASEMENT ROCK
LEGEND

- No-flow boundary
- Flow direction
- Hydraulic heads [m, a. m. s.l.]
- Gawib river and tributaries

Langer Heinrich Uranium
- Groundwater Flow Model -

Environmental Impact Assessment
*SPECIALIST INPUT*
Bittner Water Consult (Namibia) & Institute of Hydrology (Freiburg/Germany)

LANGER HEINRICH URANIUM MINE
GROUNDWATER FLOW DIRECTION IN THE BASEMENT ROCK

07/2009
FIGURE 3.13
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>
<thead>
<tr>
<th>Selected Parameters</th>
<th>WHO Guideline &amp; Namibian Group A &amp; B Guideline</th>
<th>Selected Boreholes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WW41181 WW41182 WW41180 WW41189 LH1049 LH1004 LH1177</td>
<td></td>
</tr>
<tr>
<td>Total dissolved solids (TDS) – mg/l</td>
<td>1000 6958 9210 3975 1445 7208 12938 9345</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.5 to 8.5 6 to 9 7.1 7.1 7.2 7.4 7 6.9 6.9</td>
<td></td>
</tr>
<tr>
<td>Chloride (Cl) – mg/l</td>
<td>250 3230 3905 1856 522 3468 5582 4347</td>
<td></td>
</tr>
<tr>
<td>Sulphate (SO₄) – mg/l</td>
<td>250 771 1151 460 252 628 1743 780</td>
<td></td>
</tr>
<tr>
<td>Uranium (U) – mg/l</td>
<td>0.015 0.06 0.11 0.06 0.011 0.12 0.18 0.11</td>
<td></td>
</tr>
</tbody>
</table>

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 1 mSv/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>
<thead>
<tr>
<th>TABLE 3-46: REGIONAL AIR POLLUTION SOURCES AND TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources</strong></td>
</tr>
<tr>
<td>Mining/processing operations</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Vehicle tailpipe emissions</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Agriculture activities</td>
</tr>
</tbody>
</table>
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 ten 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
ARCHAEOLOGICAL SENSITIVITY PLAN OF THE LHU ML 140 WITH EXISTING AND PROPOSED INFRASTRUCTURE

KEY

- Least Sensitive
- Sensitive
- Highly Sensitive
- Irreplaceable

Identification number for Sensitivity Zone

2 GRS 580065

Heritage Site and Site Identification Number

- Powerline
- Pipeline
- Road
- Existing Infrastructure
- Proposed Future Infrastructure
- Proposed Pit Layout
- Proposed Infrastructure

DATA SOURCE:

SCALE:

0 1,500 3,000 0 1,500 3,000

LANGER HEINRICH URANIUM MINE
ARCHAEOLOGICAL SITES

07/2009
FIGURE 3.14

L016-01
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. Social-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>
<thead>
<tr>
<th>Region</th>
<th>Erongo Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local authorities</td>
<td>Erongo Regional Council; Swakopmund and Walvis Bay Municipalities</td>
</tr>
<tr>
<td>National authorities</td>
<td>MET – Parks and Wildlife</td>
</tr>
<tr>
<td>Project location</td>
<td>Namib Naukuft Park</td>
</tr>
<tr>
<td>Closest towns/communities</td>
<td>Farmers ~15km to the north, Swakop River farmers ~50km to the west, Swakopmund ~90km, Walvis Bay ~90km and Arandis ~50km.</td>
</tr>
<tr>
<td>Catchment</td>
<td>Swakop River</td>
</tr>
</tbody>
</table>

3.16.2. Regional Social Environment

Erongo is Namibia’s sixth largest region, extending over 63,720 km². 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 (47km² in extent) and the immediately surrounding land is located in the Namib Naukluft Park (50 000km² 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).