PHASE-2 ENVIRONMENTAL BASELINE STUDY OF VERTEBRATES
IN MINING LICENSE AREA 140 (ML140) OF THE LANGER HEINRICH URANIUM MINE

Compiled for Langer Heinrich Uranium (Pty) Ltd

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Frontispiece: Husab Sand Lizard, Damara Tiger Snake, Delalande’s Blind Snake
2 EXECUTIVE SUMMARY

A baseline survey of vertebrates in Mining License Area 140 (ML140) of Langer Heinrich Uranium (Pty) Ltd (LHU) was undertaken during March and April 2009 in order to inform planning of mining and ecological restoration. ML140 is located at the boundary of two climatic zones, and vertebrates move across the area following weather fluctuations across this boundary. Several vertebrate species have their eastern or western, or their northern or southern distribution boundaries in the vicinity of ML140, therefore explaining the high diversity of vertebrates found at Langer Heinrich.

At least 44 species of mammals, 45 species of reptiles, 2 species of frogs and over 200 species of birds occur in and around ML140. Particular issues concerning individual species are outlined in relation to possible impacts by mining as well as how restoration planning should incorporate their ecological functions.

Nineteen species of reptiles are endemic to the Namib Desert or Namibia, and ten of these are of special conservation significance. Four reptiles found at LHU are either new species or will be split from existing taxa during current systematic revisions. These are the northern plain sand lizard, the Namibian Namaqua sand lizard, the Damara tiger snake (see page 1, right) and Delande’s blind snake (see page 1, bottom). The Husab sand lizard (see page 1, left), which is common at LHU, has a very small distribution range confined to the core area of the Namibian Uranium Province. The spotted desert lizard and Namib ghost gecko found at LHU are eastern outliers of coastal species. Another three reptiles are potentially threatened by pet trade, and LHU where access to poachers is limited, could represent a safe haven for such species, provided that the ones found are released at safe places.

Thirty-three different habitats for vertebrates were observed in ML140. These are described in terms of their location, physical features, environmental conditions, biodiversity, threats, restoration potential, and biodiversity sensitivity. The riparian forest in the Gawib channel has the highest mammal biodiversity of all habitats and deserves special protection. The Gawib valley and tributaries connecting to it are important to interconnect all habitats, and this connectivity needs to be managed so as not to compromise important ecological functions as well as biodiversity, particularly of mammals. There are also several special habitats with high or special biodiversity, namely, granite koppies, quartzite outcrops, an isolated sandy patch, and ephemeral water pools in a number of habitats.

Recommendations are made concerning management of vertebrate species and their habitats in ML140. A report of a specialist reptile study is presented and a proposal for the study of Hartmann’s mountain zebra.
3 ABBREVIATIONS USED FOR HABITATS IN ML140

1 = GVF = Gawib Valley Floor
2 = GCA = Gawib Channel Acacia
3 = GRU = Gawib River Upper
4 = GRL = Gawib River Lower
5 = GTL1 = Gawib Tributaries MLH, west most
6 = GTL2 = Gawib Tributaries MLH
7 = GTL3 = Gawib Tributaries MLH
8 = GTL4 = Gawib Tributaries MLH
9 = GTL5 = Gawib Tributaries MLH, east most
10 = GTS1 = Gawib Tributaries MSB, west most (Reid Wash)
11 = GTS2 = Gawib Tributaries MSB
12 = GTS3 = Gawib Tributaries MSB
13 = GTS4 = Gawib Tributaries MSB, trans-Schieferberg canyon
14 = GTS5 = Gawib Tributaries MSB, Bloedkoppie canyon
15 = PTR = Plain Tinkas Rocksculpture
16 = PLW = Plain MLH Witpoort
17 = TWC = Tumas Water Course
18 = MSB1 = Schieferberg, west most
19 = MSB2 = Schieferberg, communications tower
20 = MSB3 = Schieferberg, centre
21 = MSB4 = Schieferberg, central east
22 = MSB5 = Schieferberg, flanking GTS4 & 5
23 = MSB6 = Schieferberg, east most
24 = MLH = Langer Heinrich Mountain
25 = MTK = Tinkas Mountain
26 = FSW = Foothills Schist West
27 = FQB = Foothills Quartzite Bank
28 = FCD1 = Foothills Conglomerate Deposit, central
29 = FCD1 = Foothills Conglomerate Deposit, eastern
30 = GKP = Granite Koppies
31 = SPW = Sand Patch Westgate
4 TABLE OF CONTENTS

1 TITLE .............................................................................................................................................. 1
2 EXECUTIVE SUMMARY .................................................................................................................. 2
3 ABBREVIATIONS USED FOR HABITATS IN m140 ........................................................................ 3
4 TABLE OF CONTENTS ..................................................................................................................... 4
5 INTRODUCTION .............................................................................................................................. 6
   5.1 Background ................................................................................................................................ 6
   5.2 Location of ML140 in the Namib Desert ...................................................................................... 6
   5.3 ML140 in relation to Namib Climatic Zones .............................................................................. 6
   5.4 Connectivity of ML140 with its surroundings ........................................................................... 7
   5.5 Ecological Processes that affect Vertebrate Communities in ML140 ........................................... 9
   5.6 Vertebrate-related factors to consider for Ecological Restoration ........................................... 11
7 METHODS ......................................................................................................................................... 13
   7.1 Approach .................................................................................................................................... 13
   7.2 Study Sites .................................................................................................................................. 13
   7.3 Study Period ............................................................................................................................... 13
   7.4 Field Methods ............................................................................................................................. 13
   7.5 Assumptions and Limitations ..................................................................................................... 13
   7.6 Identification .............................................................................................................................. 14
   7.7 Description of Habitats ............................................................................................................. 14
   7.8 Level of Biodiversity Sensitivity ............................................................................................... 14
8 VERTEBRATE FAUNA AND ECOLOGY OF ML140 ....................................................................... 17
   8.1 Mammals .................................................................................................................................... 17
      8.1.1 Permanent Residents .......................................................................................................... 17
      8.1.2 Regular Commuters ........................................................................................................... 20
      8.1.3 Occasional Transients ....................................................................................................... 21
   8.2 Reptiles ....................................................................................................................................... 22
      8.2.1 Snakes .................................................................................................................................. 23
      8.2.2 Skinks ................................................................................................................................... 24
      8.2.3 Lizards .................................................................................................................................. 24
      8.2.4 Geckos ................................................................................................................................... 26
      8.2.5 Other Reptiles .................................................................................................................... 26
   8.3 Frogs ............................................................................................................................................ 27
8.4 Birds ............................................................................................................................................. 27
9 ML140 HABITATS AND THEIR VERTEBRATE COMMUNITIES .................................................... 28
   9.1 Gawib Valley Floor (GVF) ........................................................................................................... 30
   9.2 Gawib Channel Acacia-forest (GCA) ........................................................................................ 31
   9.3 Upper Gawib River (GRU) .......................................................................................................... 31
   9.4 Lower Gawib River (GRL) .......................................................................................................... 32
   9.5 Gawib Tributary #1 coming from Langer Heinrich Mountain (GTL1) .......................................... 32
   9.6 Gawib Tributary #2 coming from Langer Heinrich Mountain (GTL2) .......................................... 32
   9.7 Gawib Tributary #3 coming from Langer Heinrich Mountain (GTL3) .......................................... 32
   9.8 Gawib Tributary #4 coming from Langer Heinrich Mountain (GTL4) .......................................... 33
   9.9 Gawib Tributary #5 coming from Langer Heinrich Mountain (GTL5) .......................................... 33
   9.10 Gawib Tributary #1 coming from the Schieferberg (GTS1) ......................................................... 33
   9.11 Gawib Tributary #2 coming from the Schieferberg (GTS2) ......................................................... 34
   9.12 Gawib Tributary #3 coming from the Schieferberg (GTS3) ......................................................... 34
   9.13 Gawib Tributary #4 coming from the Schieferberg (GTS4) ......................................................... 34
   9.14 Gawib Tributary #5 coming from the Schieferberg (GTS5) ......................................................... 35
   9.15 Plain at Tinkas Rocksculptures (PTR) ....................................................................................... 35
   9.16 Plain between Langer Heinrich-Witpoort (PLW) ....................................................................... 36
   9.17 Tumas Watercourse across PLW ............................................................................................. 36
   9.18 Schieferberg slope #1 (MSB1) .................................................................................................. 36
   9.19 Schieferberg slope #2 (MSB2) .................................................................................................. 37
9.20 Schieferberg slope #3 (MSB3)............................................................................................... 38
9.21 Schieferberg slope #4 (MSB4)............................................................................................... 38
9.22 Schieferberg slope #5 (MSB5)............................................................................................... 38
9.23 Schieferberg slope #6 (MSB6)............................................................................................... 39
9.24 Langer Heinrich Mountain (MLH)........................................................................................... 39
9.25 Tinkas Mountain (MTK)......................................................................................................... 40
9.26 MLH Foothills of Schist to the West (FSW)............................................................................ 40
9.27 MLH Foothills of Quartzite Bank (FQB).................................................................................. 40
9.28 MLH Foothills of Conglomerate Deposits #1 (FCD1).............................................................. 41
9.29 MLH Foothills of Conglomerate Deposits #2 (FCD2).............................................................. 41
9.30 Granite Koppies (GKP).......................................................................................................... 41
9.31 Sandy Patch at Westgate (SPW)........................................................................................... 42
9.32 Ephemeral Pools................................................................................................................... 42
9.33 Quartzite Outcrops................................................................................................................ 43

10 RECOMMENDATIONS ON MANAGEMENT OF VERTEBRATES AND THEIR HABITATS........ 44
10.1 Recommendations concerning Species................................................................................. 44
10.1.1 Mammals...................................................................................................................... 44
10.1.2 Reptiles ........................................................................................................................ 45
10.1.3 Birds............................................................................................................................. 46
10.2 Recommendations for Habitats and Ecological Restoration ................................................... 46

11 ACKNOWLEDGEMENTS.......................................................................................................... 48
12 REFERENCES.......................................................................................................................... 48
13 APPENDIX A: MAMMALS AND THEIR HABITATS IN ML-140 OF LHU................................. 50
14 APPENDIX B: REPTILES AND THEIR HABITATS IN ML-140 OF LHU ................................. 51
5 INTRODUCTION

5.1 Background

In order to inform future mine activities and plan restoration in relation to environmental issues, it is important to conduct baseline studies of biodiversity sensitivity as soon as possible in the mining process. This serves to identify implications of mining activities, and planning can therefore either help avoid unnecessary negative impacts, or undertake mitigation measures. Where neither is practical, it serves to inform on the nature of the impact and its implications, and can provide critical background information for later restoration of viable ecosystems following mining.

In March 2009, LHU commissioned a biodiversity baseline study of the entire Mining License Area 140 (ML140) for completion in April 2009. This report contains the vertebrate component of this study, which should be read together with the other biodiversity reports (Irish, 2009; Strohbach, 2009). The primary aim of this study is to obtain baseline data and to develop decision-making tools for the mine, that will allow them to assess the impacts of their activities and will feed into the development of a future restoration plan.

Section 8 of this report describes the vertebrate fauna that occurs or is expected to be found in ML140. Except for birds, this report describes fauna at the level of species or groups. Features of the ecology of these animals that are important for the ecology of the area are described together with aspects relating to their conservation. Subsections describe the different vertebrate taxa, and the different kinds of impacts of mining and mining-related activities are discussed where these are applicable to certain species or taxonomic groups. Furthermore, features that could be important for restoration are analyzed.

Section 9 of the report describes the different habitats, their vertebrate communities and biodiversity sensitivity levels. This is done in broad sweeps with the goal of recognizing the key features of each habitat, how different mining activities could impact these features, and what the implications of habitat loss would be for the local ecology as well as for the Central Namib Desert, for Namibia and beyond. Along the same lines, points are made concerning ecological restoration.

Recommendations derived from the detailed analyses in sections 8 and 9 are summarised in Section 10.

5.2 Location of ML140 in the Namib Desert

LHU is located in the hyperarid Namib Desert, and receives less than 50 mm of annual rainfall on average. Its eastern boundary is a steep topographic gradient, the Great Escarpment, where average rainfall quickly increases up the gradient to 100 and 200 mm per annum. Namib organisms need to be tolerant of long periods of extreme drought interspersed by brief torrents and highly localised flushes in productivity.

Ephemeral rivers cut through the Namib. These are normally dry rivers that are tree-lined linear oases, enabling a host of organisms to penetrate far into the desert and from these rivers to move into adjacent areas. The rivers and the areas between them can be seen somewhat like different mega-patches arrayed along the length of the Namib from south, starting in the Namaqualand of South Africa to the north, ending in Iona up to Benguela in Angola. LHU is located near the centre of this array, and is situated near the Swakop River, a relatively narrow canyon with a well-developed riparian forest.

5.3 ML140 in relation to Namib Climatic Zones

From west to east, the Namib Desert has several different climatic zones, dominated in the west by regular fog, low-lying moisture, relatively cool temperatures and steady west winds, and dominated in the east by the sporadic occurrence of rainfall, at least some falling annually, but otherwise very dry air, hot temperatures and variable winds. These extremes are delineated into zones, ranging from the coastal zone (from the beach to 20 km inland), to the inland foggy zone (20-50 km), the middle or minimal zone (50-80 km), the eastern Namib (80-120 km), and the pro-Namib that extends to the escarpment.
The location of LHU straddles the borders of two zones: the so-called “minimum desert” climatic zone, the area of the Namib that receives the least total amount of water from both rain and fog – but a bit of both – and the “eastern Namib” climatic zone, where at least some rain falls in most years and dew is more frequent. The Langer Heinrich Mountain and Schieferberg mark the boundary of these two zones. Vertebrates from each zone can penetrate into the neighbouring zone, particularly when conditions change (e.g., eastern Namib species going west following rains, western Namib species going east during droughts). LHU is therefore at an important transition zone, and the Gawib valley, oriented east-west would normally be a very important corridor for the temporal dynamics of this boundary.

5.4 Connectivity of ML140 with its surroundings

The details of the greater and immediate surroundings of ML140 (Figure 1 & 2) are important, as they affect the local distribution of species and the viability of local populations. These features include the numerous minor and major tributaries that connect to the Swakop River. The Gawib River, which drains the main portion of ML140, is one such tributary. The Tinkas River drains the eastern quarter of ML140. The Tumas catchment, a minor ephemeral river crossing the Central Namib, drains the western tip of ML140. Perennial vegetation lines follow the main drainage lines of the above-mentioned rivers, and these can serve as important corridors for animals requiring food and shelter along the way.

While water courses run east-west, many mountain ranges and their intervening plains have north-south connectivity. Given that many vertebrates are substrate specific, preferring to live either in rocks or in areas with stones and gravel, or in sand, the spatial array of these substrates can either represent barriers or dispersal directions for such populations. These connections are important when considering how isolated populations at LHU could be.

The two principal mountains, Langer Heinrich Mountain and Schieferberg, comprise quartzite and schist respectively. Ranges of the same rock type occur north and south as well as east of ML140, in other words, similar geological features occur elsewhere. However, the surrounding landscape features connecting to these, and the climate (in the case of the eastern mountains) differs from that of the mountains at Langer Heinrich. Therefore, the particular configuration of these two mountains, separated by a valley containing a riparian forest, has a unique combination of features that affects the vertebrate community occurring there in a particular way. The distribution ranges of several species have their boundaries in the vicinity of ML 140, most typically being an east-west boundary, but some are at their northern or southern boundary. This is reflected in a high biodiversity of vertebrates.

Wind moves material across landscapes. Dominant winds are from the south-westerly direction during summer and north-easterly direction in winter, these being redirected to west and east up and down the Gawib Valley. Winds carry aerosols, dust, sand, salts, moisture, as well as organic material such as detritus and many kinds of seeds. The interaction of wind with surfaces influences wind erosion and deposition, and features such as hummocks or isolated sandy islands are built over time due to constant winds. Structural changes in the landscape, including mining-related activities, can change the winds and cause extensive changes in the surface dynamics downwind, and this can affect habitats for vertebrates; this can be nearby or a very long distance away (up to 100's km away especially where materials are eroded, before they are deposited). Mine planning should take such potential changes into account.

Availability of fresh drinking water is a key factor for many mammals and birds, particularly the larger species, and affects their movements. There are no perennial water holes in ML140, but some long-lasting water holes occur in the Langer Heinrich Mountain, the Gawib spring north of the ML, and in the Tinkas River east of the ML. Tinkas dam, Gemsbokwater and Hotsas are the closest artificial water points provided by MET (Figure 1), while the Arisab water point in the Swakop valley is dysfunctional. Mining-related activities by LHU has recently created several artificial water pools in ML140, such as the tailings dam, open reservoirs with waste water and with Swakop River water, as well as short-term puddles resulting from the mining-related use of water.

Connectivity across the landscape is a key for the conditions of groundwater, ephemeral pools, and to some extent also the near-surface water in the soil. A specific place in a water course should therefore
always be viewed in the context of the entire stretch of water course located upstream. Blockage at any point can affect a long stretch downstream in that watercourse; cessation of hydrological processes can affect distant places. Mining in ML140 should be planned such that hydrological function of watercourses can eventually be restored.

Figure 1: Map of area surrounding LHU. Approximate locations of the road (red line) and ML140 (yellow line) are indicated.

Figure 2: Map of ML140
5.5 Ecological Processes that affect Vertebrate Communities in ML140

Animals that occur in ML140 require resources and suitable living conditions. Their existence is dependent on interplay between their physical environment, resources (food, water, shelter), populations of conspecifics and community processes, including trophic interactions (food webs). At any one time, biotic communities can therefore be said to be in a specific “state”, or average/typical condition, about which factors vary, even if this is somewhat unpredictable. This state allows one to characterise the ecology of a local biotic community in terms of its biodiversity and populations of different species. These communities are somewhat resilient, and to some extent defined by small levels of disturbance within the limits of resilience, but gross disturbance can change the conditions to a different stable state. Good understanding of the drivers and dynamics of factors that determine ecological states are necessary in order to manage impacts and restoration.

The physical environment can be characterised in terms of macro- and micro-topography, aspect (slope and its orientation), and the geophysical and geochemical characteristics of soil. These characteristics affect microclimatic conditions, i.e., a mosaic of different scales of the availability of different conditions of temperature (shaded vs sun-exposed side, light substrate vs dark substrate), moisture (fog-wetted side, moist base of stones, dry shelter from floods), ground and soil moisture (often dependent on upstream conditions) exposure to wind (windward and lee side, affecting erosion and deposition of dust/sand and of seeds and detritus), and the ability to penetrate the ground (e.g. going into cracks or burrowing). For many animals, the availability of several different conditions from which to choose from at any one time is important; thus they may move to and fro between patches of differing microclimatic conditions so as to thermoregulate or to satisfy different needs. A single habitat can therefore be described in terms of these characteristics, as well as the characteristics of adjacent habitats. Different mining-related activities change the physical environment, ranging from extreme localised changes (e.g. mine pit, rock dumps, tailings), to smaller modifications (e.g., roads, buildings).

The availability of moist microclimate in underground burrows or underneath stones is critical for many desert animals, as it gives them temporary respite from the desert. Stable soil has established particular conditions of moisture due to the interaction of above-ground and below-ground sources of moisture with the soil over aeons, and this could, for instance, be the very factor maintaining the surface crust of the desert pavement, which, in turn plays a critical role in conserving near-surface moisture (Kaseke, 2009). Subsurface layering of soil, especially the calcrite and gypsum horizons, are likewise important for the below-ground moisture regime (Walter, 1994). Large-scale changes in the soil structure, as during mining, changes the layering of the soil and the associated moisture regime. During restoration, it will be important to recreate a soil moisture regime that is conducive for burrowing animals, as a suitable temporary respite from the dry desert conditions is critical for many.

Physical conditions, in turn, affect the resource availability and requirements of animals. Nutrients, energy, water, shelter and the absence of toxins are the basic resources, allowing individuals to survive and, if sufficient, to grow and reproduce. The dry conditions and temperature extremes of the Namib Desert result in resources often being scarce, and the ability of animals to cope in terms of their ecophysiology and behaviour is important (Henschel et al, 2001). Even in an area as variable and frequently extreme as the desert, there are limits to the ability of animals to cope, although their resilience is notoriously high. Thus, many desert animals can survive without drinking water for a long time, or indefinitely, as long as they can derive moisture from food, conserve water in their bodies and retreat into moist, thermally stable burrows. Many can tolerate hunger for a long time, but may end up in a fatal subliminal energy/nutrient trap if deprived of food for too long: they no longer have the energy or health required to procure the energy they need. Disturbance may cause animals to use more energy than normal, making it more difficult for them to maintain themselves or their population, and cause gradual degradation. If mining-related environmental changes are within the ecophysiological tolerance limits, animals can continue to thrive. If the mining-related impacts exceed these tolerance limits, animals die or otherwise depart from the area, if not immediately then over time. When considering biodiversity sensitivity of an area, it is important to understand these limits.
Space also affects the availability of resources, i.e. an animal needs to have a **home range** big enough to satisfy all its needs. A particular home range may straddle several habitats, each of which satisfies some but not all needs. Water, in particular, occurs in only few places in the desert, and animals who feed at remote places often go to considerable lengths to get to water (and the nutrients/salts often available with or near water). Only a small section of the home range (and season) may be of sufficient quality to support demanding offspring and to reproduce successfully. The different resources within a home range need to be interconnected, so that an animal can reach these at the required time. Mining-related activities can interrupt this connectivity, and therefore render a much bigger home range unviable for its resident. In ML140, this connectivity can be adjacent habitats (e.g. sheltering rocks next to productive water courses, or habitats at different temperatures due to differences in exposure to sun or differences in rock colour), or it can involve places located on either side of ML140, and animals need to traverse the ML to reach these lest their home range become unviable. Knowledge of this connectivity is required in order to contain and mitigate impacts and plan effective ecological restoration.

Living organisms are members of **populations**, individuals interconnected by gene exchange, who collectively form a viable (re)productive unit over many generations. The conditions of gene flow is important, as small isolated pockets of conspecifics (members of a particular species) share the same fate and may all die if conditions in that pocket are temporarily no longer conducive to sustain the local population. Although it is true that founder effects result from successful mini-populations, sometimes leading to new species, genetically isolated and different from other species, most isolated mini-populations are unsuccessful, they die. Connectivity of a particular site with adjacent sites is usually critical for healthy populations. Extinction of one patch can have cascading effects on other patches. This can be clearly illustrated for animals that live in sedentary colonies, such as the hyrax and Namibian rock agamas of ML140, but also applies to many other species. In terms of mining, this means that where disturbance negatively affects a particular species, it is important to maintain the connectivity between other sub-populations so as to contain the impact and to maintain the potential for population recovery upon restoration.

The **biogeography** of a species is defined by its geographical range and the habitats it occupies within this, all interconnected in viable populations. This range differs between species, and, as indicated, some species in ML140 are at their distribution boundary; a change of habitat in ML140 may change the distribution range of a species, or the connectivity across the population, resulting in biogeographic changes of the species. Of particular concern in terms of conservation are species with very small distribution ranges and very special ecological requirements that do not tolerate the loss of a particular (part of) habitat or loss of a particular ecological requirement and where such loss may threaten the conservation status of such a species. Where species have been described, some knowledge exists concerning their distribution range, habitat and ecological requirements; there is no such information for a previously undescribed species, and it is therefore important that this is obtained in such cases. It is of benefit to all concerned that LHU promotes ecological studies, as this improves the ability for the LHU to plan best practise for mining, while also helping to extend knowledge of species and ecological processes in the Namib Desert.

Living organisms are members of **biotic communities**, i.e. all the plants and animals in an area that together with the physical environment form an ecosystem. Biotic communities are not only the total of all species occurring in an area, they also involve complex interactions between many of its components. The most obvious interactions are trophic, the i.e. the location(s) of a species in a food web, either as consumer or the consumed. However, a host of other interactions is also important, ranging from competition, to facilitation (one individual or species somehow affecting conditions in such a way that it favours another individual or species). Many species, for instance, dig holes or produce dung, which enables other species to live in an area. The extreme case of facilitation is a keystone species, namely a species that plays a fundamental role in structuring biotic communities, regulating rates of ecosystem processes, structures landscapes or serve as essential links in food webs. Most of the structural and functional properties of desert ecosystems are dependent upon only a few keystone species. Take away even one keystone, and the entire system changes. Introduce a keystone (as during restoration), and a lot of other things may follow. An example of a potential keystone species in ML140 are large, mature *Acacia erioloba* trees; if they were to disappear, many other species would disappear, particularly animals...
that feed and shelter in these trees, or consume animals that live on or under the trees. Another example could be mountain zebra, which traverse most of the ML, transport nutrients (dung), and regularly cause localised mini-disturbances; remove them, and many dung-feeders, or plants growing in places where zebra trod or rolled, may disappear. Biotic communities in ML140 are not discrete units, but change across habitats, with many elements straddling several habitats in different ways. Because they are so complex, biotic communities make the analyses of mining-related impacts most difficult to predict and manage. This complexity cautions that where the extent of damage on a community is unknown, the precautionary principle should be adopted. Viable biotic communities are often the target condition of ecological restoration, and where this will be impossible to achieve in the conditions prevailing in the Namib Desert, alternative target conditions should be planned. Extensive research will be required to achieve this in habitats and communities as complex as ML140.

The biodiversity of areas, or the complexity of food webs, are proxies for different ways of expressing the nature of ecological processes prevailing in an area. In the current report these are simplified into four levels of sensitivity. The level of highest sensitivity is either the most complex level, or where changes in key processes would cascade, or where species of special conservation significance occur. The level of lowest sensitivity is merely expresses that, based on current knowledge, heavy localised impacts are not likely to cause damage beyond the terrain where this is done. However, even this lowest level should be seen in the light of the complexity and interconnectivity of ecosystems as outlined above, and should be minimised and restored to the best ability where feasible and possible. The overall effects of local impacts are difficult to predict, although, based on our considerable knowledge of the Namib Desert, and our assessment of the different habitats and species occurring in ML140, we have attempted our level best to improve the environmental planning process of mining by LHU so as to advance best practise.

5.6 Vertebrate-related factors to consider for Ecological Restoration

The above-mentioned processes are important for planning ecological restoration, which should be commenced during the perational phase and continue once the mining-related impacts have ceased at a site. Aspects to consider are the individual species, their conservation status, and space use. At a site, the key ecological processes comprise availability of resources and suitable living conditions, in relation to the physical environment, and the different conditions of nutrients, energy, water, shelter and absence of toxins. Also important is the degree and nature of the connectivity of a habitat to its surroundings, and how a site is used to interconnect locations with different resources that vertebrates require. Animals occurring at a site should not be isolated from other members of the population, and gene flow should be maintained. Especially for clumped of colonial species, metapopulations and their interconnectivity will be an important consideration for re-establishing viable populations at a restored site. Restoring viable, complex biotic communities will be a big challenge, and it is important to gain some understanding how species affect other species in order to restore ecosystems. It is highly recommended that a good understanding of ecological restoration at ML140 is gained as soon as possible so that further impacts can be avoided or mitigated accordingly. This should be achieved by conducting research on key biotic elements and processes and then testing these progressively on the sites where mining activities have been concluded; lessons learnt can then be accumulated. Examples of aspects that might be considered for restoration research are given throughout the remainder of this document in relation to different taxa and habitats.

6 SCOPE OF WORK

LHU outlined the following scope of work:

- Conduct a rapid assessment of the vertebrate communities for the entire ML, using a similar approach to that adopted for the Phase I biodiversity studies conducted in 2008.
- Both rodents and lizards have small home ranges and are both primary and secondary consumers. They may therefore prove to be good indicators for restoration. In addition some, e.g. Husab Sand Lizard, are important from a conservation perspective. For this reason it will be valuable to undertake a more detailed survey of rodent and lizards within the ML. Specifically the questions to be addressed are (a) What is the structure and composition of small mammal and reptile communities? (b) What are the most important ecological processes that maintain small
mammal and reptile communities? (c) What are the critical issues to consider in restoration of small mammal and reptile communities? (d) Which aspects of the small mammal and reptile communities can be used as indicators of restoration progress?

- Conduct a specialist report on reptile species of special conservation significance following the recommendations of initial fieldwork. This specialist report should: (a) identify reptile species using DNA techniques; (2) evaluate the impacts of mining-related activities on these species; (3) recommend how to avoid, mitigate or restore the impacts.

- In the report include a description of the composition of the various vertebrate habitats and communities. Ensure that the description is placed within a national and regional setting. It is important to get a good idea of whether the communities found are well represented in the Namib, if the habitats might be important refugia in the light of climate change etc. Whilst LHU needs to scale down to specific habitats so that biodiversity issues can be included in mine planning, the true consequences of the decisions made will only be understood if the area is viewed within the context of the greater landscape.

- In the report describe the basic ecosystem dynamics of these habitats. It is essential that this baseline study is not limited to a list of the species found in an area but gives some insight into what ecosystem processes make it possible for these species to exist in this area. Identify what the key ecological drivers are, i.e. what maintains ecosystem patterns and structure such as seasonal flow of water, dust carrying nutrients, wind carrying detritus etc. The key vulnerabilities and threats to vertebrate communities should also be raised. This will probably need to be done at a scale greater than the ML to make sense. The aim is to start developing an understanding of the area as a dynamic landscape. This will be particularly important when undertaking the assessment for the EIA and for the development of the restoration plan.

- In the report include a sensitivity assessment. In other words, identify which habitats are more sensitive to disturbance from mining activities than others and outline why this is the case. When assessing the sensitivity please describe the methodology used and apply it uniformly across all habitats. For example if you consider four criteria (species diversity, conservation status, rarity of habitats, restoration potential) then ensure that each unit (habitat or community) being assessed is assessed in terms of each of the criteria. Address the bottom-lines and non-negotiables.

- Develop a vertebrate habitat plan map for the entire ML.
- Compile a vertebrate sensitivity map.
- Develop both plans in conjunction with LHU’s GIS consultant (Katharina Dierkes of Maproom) so that the vertebrate plans can be laid over the vegetation and invertebrate plans in order to form an overall biodiversity plan.
- In the report give an indication of the critical issues to consider in restoration of vertebrate communities, and give an indication of how reversible impacts are over a period of 5-10 year as this will give a sense of which communities are more easily restored than others. If possible suggest which vertebrates might be easily applicable indicators of restoration progress and describe what aspects of the vertebrate communities can be used to monitor restoration progress.

- The phase-1 study revealed that Hartmann’s zebra are found within the ML. However, their home ranges extend beyond the boundaries of the ML. If the ML contains habitat features that are key for their survival and the mining activities either destroy or degrade that habitat feature, the particular species may be impacted even though the actual number of individuals that are affected is relatively small compared to the number outside the ML. It is therefore important to establish (a) if mining activities (may) disproportionately affect a large number of the local herds’ viability over the longer term, (b) if the ML represents a key/ vital feature of their habitat, or represents a critical spatial linkage between sub-populations. To do this we therefore need to quantify that risk by studying the species’ population structure, herd structure (where applicable), seasonal spatial distribution and seasonal movements. Whilst these issues could be applicable to other mammals too, at this stage the study will be restricted to zebra.

- Assess the impacts of the existing facilities/operations as well as the proposed activities (to be supplied by LHU) on vertebrate communities. Assess the impacts on vertebrate communities within the ML and beyond the borders of the ML (if applicable). As part of the expansion, the existing water pipeline from the Swakop River is being upgraded to improve the reliability of water transfer and to maximise output. The impact of this upgrade will also need to be assessed.
Increased traffic is expected on the road between the Walvis Bay harbour and LHU site as a result of the expansion. An assessment of these impacts must also be included. All phases of the project cycle, namely construction, commissioning, operations and closure need to be considered when undertaking the assessment.

7 METHODS

7.1 Approach
Sites located across the length and width of ML140 and to the north (Langer Heinrich Mountain) and south (Schieferberg) were assessed over three days to characterize habitats and vertebrate communities, a priori based on substrate (sand, gravel, granite, schist, quartzite, calcrite) and topographic features. The occurrence of fauna was recorded from direct observations of the creatures and signs of presence and noted potential occurrences based on knowledge of the area and habitat requirements of fauna in whose distribution range ML140 is known to fall. An initial assessment of properties in relation to animal communities was made according to aspects given in the scope of work.

In order to characterize communities, more detailed studies were conducted over the course of five days at specific sites of special significance as identified in the initial 3-day assessment.

7.2 Study Sites
A satellite image of ML140 and a geological map provided a convenient overview of important landscape features. Representative examples of these features were visited, as were places that were expected to be of special significance in terms of vertebrate biodiversity or were expected to be key locations for particular ecological functions. The result of this habitat assessment is presented in section 9.

7.3 Study Period
Fieldwork was conducted on 23-25 March and on 4-8 April 2009. This followed rainfalls earlier in the season, so that vertebrate activities and population numbers were expected to be favorable. Hot, dry wind conditions on some field days may have somewhat suppressed activity of some vertebrate species.

7.4 Field Methods
Over the course of eight fieldwork days, we visited selected representative places throughout ML140 in order to record vertebrates and note habitat characteristics. On four afternoons we deployed Sherman traps for live small mammals and checked them the next morning. We photographed vertebrates and hand collected species where this was needed to confirm identification. Collected animals were either released after identification, or killed and preserved in 70% ethanol (which preserves animals in such a state that DNA analysis is possible, if required). Thrice we conducted night observations to observe nocturnally active vertebrates.

7.5 Assumptions and Limitations
A subject as complex and diverse as vertebrate communities cannot be properly investigated in an area of this size within a period of a few days. In particular, despite the increased effort, we were not likely to encounter all rare, cryptic, secretive or nocturnal species. It was difficult to see many of the small species. Furthermore, seasonal and annual changes were not taken into account. The time of year (end of summer, start of Bergwind conditions) of the current study may have affected activities, particularly of reptiles, but the effects of rainfalls of a few weeks earlier were still very prominent in terms of plant biomass and may therefore have increased small vertebrate populations. Unusual grass cover had, on the other hand, negatively affected chances of detection.

It was therefore necessary to make some assumptions, including that the relative biodiversity detected in different sites reflected the overall differences in biodiversity between sites. Especially in the case of areas here designated as being least sensitive, it is unknown whether this conclusion would hold for all seasons. A high degree of uncertainty remains concerning the possible presence of rare species of
special conservation significance that were not detected. However, such species are also expected to be associated with areas that have been identified as highly sensitive for other reasons, and the sensitivity map may therefore not be affected.

For large mammals in particular, more detailed observations of key resources would provide better clarity concerning the importance of a particular site either for provision of resources or as traffic corridor when commuting between different resources.

7.6 Identification

Species were identified according to my expert judgment with assistance of applicable literature (Stuart, 1975; Apps, 1996; Branch, 1998; Griffin, 2003; Skinner & Chimimba, 2005; Griffin & Coetzee, 2006; Henschel et al., 2006; Alexander & Marais, 2007; Stuart & Stuart, 2007).

Tracks and dung of all the game animals known to occur in the area were diagnostic (provided tracks were recent and clear). Hartmann’s mountain zebra, in particular, develop networks of trails across slopes. Dassie rats, *Petromus typicus*, leave conspicuous yellow-white urine stains outside den entrances. Dropings and tracks of small mammals can only indicate the possible group these belonged to. Thus, faeces the thickness of a human small finger with hairs and insect remains indicates a small carnivore, but not which species. Likewise, many shallow foraging digs indicate that some small carnivore was looking for grubs or geckos; the number and distribution as well as other signs can indicate whether this animal was social (e.g. suricat) or solitary (e.g. polecat or slender mongoose) and literature-derived or personal knowledge of species ranges and habitat preferences can inform the tentative identification. Certain types of bone damage can only be caused by hyaenas, being a sure method of identifying their presence. It was only possible to identify reptiles from direct sightings and from burrows of barking geckos. Shed skin was not found. The presence in the general area of LHU (mainly the current area of mining activity) of some vertebrates was determined by identifying photographs provided by the LHU SHER department. Presence of numerous snakes is indicative of an abundance of prey, mainly other lizards, geckos and mice.

7.7 Description of Habitats

Environmental features relating to vertebrates that were used to describe different habitats were:
- Substrate surface hardness and penetrability, including hard rocks, stable layered soil with imbedded stones, softer ground with loose stones, to loose sand. Substrate characteristics affected the ability of vertebrates to dig into the ground for shelter or food.
- Degree of surface complexity and spatial discontinuities such as cracks, holes, mounds, overhangs, protective barriers or different physical levels of the accessible substrate. This ranged from relatively smooth plains, vegetation mounds (hummocks), flaky-barked many-branched shady trees, to highly complex shapes of rocks and spaces between them. This affected the availability of shelter in a habitat as well as the accumulation of potential food.
- Landscape characteristics, including topography and geology, and of the adjacent areas. Slope and aspect as well as substrate type affects microclimate, and topography affects the ability to move effectively across an area as well as vigilance distance.
- Occurrence of potential food.
- Occurrence of water.
- Occurrence of predators.
- Use of an area by different species.
- Community composition.

7.8 Level of Biodiversity Sensitivity

The International Union for Conservation of Nature (IUCN) provides guidelines for assessing the conservation status of species (IUCN 2005) and regularly publishes lists of endangered species (e.g. IUCN 2000). The status is determined based on numerous criteria and requires information on a species of the range (area) where the species occurs, number of records made, and what the trends are in terms of abundance and range, availability of suitable habitat and the number, location and security of
subpopulations. This status then allows one to assess how impacts in a specific location may affect the species as a whole. In the current rapid assessment it was possible to flag species that were encountered and to designate levels of sensitivity from information available from the field and literature. National checklists for mammals (Griffin & Coetzee, 2006) and reptiles (Griffin, 2003) were consulted. Information on the distribution of species according to literature sources (identification books, op.cit.) indicated the regional occurrence and whether observations at LHU were near the centre, the boundary or beyond previously recorded distribution range of species.

Another criterion used in the current assessment was the expected biodiversity in a given area (high, medium, low), i.e. number of species and their abundance. High abundance of a species in several study sites may change the assessment rating in a given site, as many individuals of a species would still be present in nearby sites if a particular site is damaged. A further criterion used to assess sensitivity was the importance of a particular site for movements of a species from one site to another and how critically this may affect the local population(s) in ML140. The ability of species to recover following impact, or to play an active role in the ecological restoration was also a factor for assessing sensitivity.

Sensitivity furthermore depended on how common a particular habitat was, ranging from high sensitivity for unique or localised habitats to lower sensitivity for widespread habitats. The ability to restore the vertebrate biodiversity in a habitat was also factored into the sensitivity index.

The vertebrate sensitivity of a habitat, being the combination of the above factors, falls into the four categories listed in Table 1. A sensitivity rating was given based on the conditions listed; if a condition from a higher category was important it elevated the rating.

Table 1: Different levels of sensitivity of the study sites:

<table>
<thead>
<tr>
<th># sensitivity</th>
<th>Condition</th>
<th>Impact of mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 least sensitive</td>
<td>- few species</td>
<td>site degradation would be loss of space for a few species of least concern</td>
</tr>
<tr>
<td></td>
<td>- no species of special conservation status</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- usually low abundance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- site not important in home range of any species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- it should be possible to restore the habitat to an acceptable target condition</td>
<td></td>
</tr>
<tr>
<td>2 sensitive</td>
<td>- biodiversity is fairly high</td>
<td>site should not be permanently damaged and should be used in such a way that ecological function can be restored</td>
</tr>
<tr>
<td></td>
<td>- and there are no species of special conservation concern</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- and/or proximity to a site of higher sensitivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- and/or conduit for movements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- with further research and good future planning, it should be possible to restore the habitat to an acceptable target condition</td>
<td></td>
</tr>
<tr>
<td>3 Highly sensitive</td>
<td>- biodiversity is high</td>
<td>can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed</td>
</tr>
<tr>
<td></td>
<td>- and/or species of special conservation concern occur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- it will be difficult to restore the habitat and its biodiversity</td>
<td></td>
</tr>
<tr>
<td>4 most sensitive irreplacable area</td>
<td>- biodiversity is high</td>
<td>mining-related activities have negative effects and should not be undertaken</td>
</tr>
<tr>
<td></td>
<td>- and the site is critical for populations of species of special conservation status</td>
<td></td>
</tr>
</tbody>
</table>
* The “most sensitive” level flags an area as being of special biodiversity significance where conservation should have priority (with no or very few, low impact activities allowed), hence the recommendation that such an area is designated as an “irreplaceable area”.

Figure 3: Map of vertebrate habitats in ML140, as described in section 9.
8 VERTEBRATE FAUNA AND ECOLOGY OF ML140

This assessment of vertebrates focuses on mammals and reptiles, and data or informed opinion on expected occurrences of species from these groups are collated from literature as well as from observations by the current study team or by SHER staff. This report therefore includes a potentially complete species list of mammals and reptiles in ML140 with the observed or potential occurrence in various habitats, based on what was ascertained within the timeframe of the current study. The same is done for frogs. Ecological background is given for these groups, pertinent to the scope of this study. This section focuses primarily on the needs of the organisms to sustain populations in the area, with notes on their vulnerability of being impacted by mining and on some of the effects and functions of these animals that could inform restoration planning.

A thorough investigation of birds at species level would have required detailed, observations far beyond what was possible within the framework of the current study; it would also have required more time as many birds only use the area seasonally. Compared to mammals (44 species) and reptiles (45 species), birds are far more numerous in species (one can expect about 200 species at this transition of climatic zones; there are 196 bird species at Gobabeb, which is drier than LHU; Henschel et al. 2006). Birds are much more mobile and more able to avoid or compensate for disturbance at certain sites than most other animals. Birds are very important for the ecology of an area, and although no species-by-species treatment was possible within the current timeframe, some key needs and effects of birds as a group are noted. Some birds have very specific requirements for nests in certain habitats in the study area, and it is these requirements that this study concentrates on. Furthermore, many birds are attracted to water and the artificial water available as a result of mining activities may affect the use of ML140 by birds.

8.1 Mammals

For mammals, ML140 may either serve as permanent living space with all required resources, or as a passage to travel through. In both cases it is important to establish how critical these functions are for the populations of these species. A third category of mammal species are occasional transients, species that do not normally have viable populations within the ML, and whose use of the ML does not appear to be critical for their populations elsewhere. This section is divided according to these three categories. An overview of the 44 mammal species of ML140 is given in Appendix A.

8.1.1 Permanent Residents

Elephant shrews – Several elephant shrews were seen in the granite koppies, and one was identified as the bushveld elephant shrew, *Elephantulus intufi*. This species requires a combination of protective spaces under rocks adjacent to suitable forage for insects under shrubs, a combination also found along water courses from the mountains. Round-eared elephant shrews, *Macroscelides proboscideus*, are also likely to occur in ML140, and would be found in more open country near small rocky ridges on the plains or in the Gawib valley. Both species are expected to have denser populations further east in the Tinkas area and loss of habitat at ML140 would not be disastrous for the local populations.

Hyrax, *Procavia capensis* – occur in larger areas of granite koppies (e.g. SE border of Gawib Valley and Tinkas Rocksulpture Trail) and in Langer Heinrich Mountain. They browse on shrubs and trees located near their rocky retreats and undisturbed areas that will sustain this browsing all year round are critical. They have several predators, and large raptors such as Martial Eagle, seen near LHU, may feed on hyrax. Colonies are very localized and in the Namib, interconnectivity between colonies is a problem. Loss of a colony, e.g. in Langer Heinrich Mountain opposite LHU, could impact negatively on colonies located further west.

Cape hare, *Lepus capensis* – live on the open plains, provided they can find shelter under a shrub or large tuft of grass by day, and are found throughout the open areas of the Gawib valley and channel. Hares would avoid disturbed areas and move elsewhere on the plains. Disturbance of hares from their retreats by day exposes them to predation, particularly by raptors, and such disturbance should be avoided.
Jameson’s red rock rabbit, *Pronolagus randensis* – was only seen once, but their numerous distinctive droppings in latrines indicate that they are common in all rocky areas of ML140. These secretive animals are good at quickly finding alternative retreats when disturbed, and mining may merely represent loss of territory. The Namibian subspecies is near-endemic, with a distribution range along the northern part of the Great Escarpment and the adjacent mountains, such as the Langer Heinrich Mountain and the Schieferberg, in both of which it is common. Rather little is known about this rabbit.

Dassie rat, *Petromus typicus* – require horizontal crevices under rocks and a range of fresh grass, herbs and small shrubs, from which they eat the leaves, flowers and fruit. They are dependent on water from their food, and in dry conditions may obtain this by feeding after fog or dew. Dassie rats are easily disturbed and avoid noise pollution or places where perpetual disturbance by day prevents them from sun-basking in peace, a critical activity for physiological reasons (Withers, Louw & Henschel, 1980). They have already abandoned sites next to the mine plant, pits and roads. This species, although common, is very special if not iconic. It is the only member of the family Petromuridae, and this exceptional family is unique to the Namib and its escarpment. If disturbed areas remain physically intact, this species may return from adjacent rock sites, but little is known of the social system and dispersal behaviour of this species.

Ground squirrels – While the South African ground squirrel, *Xerus inauris*, was recorded on the plains of Tinkas Rocksculptures, the Damara ground squirrel, *Xerus princeps*, establishes its warrens into the edges of koppies and hills. The latter species was not observed, but could occur around the granite koppies and the boundary of plains and foothills of Tinkas Mountain. Damara ground squirrel is endemic to the eastern Namib and escarpment. The feeding behaviour of ground squirrels as well as their extensive digging activities change the soil and vegetation composition on the plain, and this heterogeneity increases diversity. Other animal species, such as suricats, mice, lizards, snakes, spiders and beetles, make use of the ground squirrel’s burrow systems either while occupied or unoccupied. In an ongoing project on ground squirrel under the auspices of the Gobabeb Training and Research Centre, Prof Jane Waterman (pers.comm.) considers ground squirrel to be keystone species, akin to the prairie dog of America, and they facilitate the ability of many other species to live in the area. Ground squirrels readily habituate to human activities and would tolerate some degree of local disturbance. The ML140 ground squirrel colonies are part of a larger population of the Tinkas and Hotsas plains, and mining would represent temporary loss of territory. The role of ground squirrels as potential ecological engineers could be usefully employed in restoration.

Four-striped grass mouse, *Rhabdomys pumilio* – is the most common rodent of the Gawib Valley. This diurnal mouse burrows under shrubs and Salvadora hedges and into hummocks, darting between shelters to forage. They are omnivores, feeding on fresh plants, seeds as well as insects. Their population quickly adjusts to the availability of the above-mentioned shelter and food. These mice are important prey for raptors and carnivores. On a much smaller local scale than for ground squirrels, but therefore across much more area and different habitats of ML140, the burrowing activities of these mice turn over soil and empty burrows are retreats for many other animals, critical shelters for those that cannot dig burrows themselves. Namib *Rhabdomys* populations fluctuate, typical for mice, and they therefore have an inherent capability to repopulate previously vacant space.

Southern multimammate mouse, *Mastomys coucha* – may naturally occur in the area but were not observed. The mine buildings as well as any food found there would benefit their population, which can breed up quickly and become a pest. If these mice consume insects contaminated by mine-related chemicals, and the mice are captured and consumed by raptors, pollution could spread from the mining plant.

Black-tailed tree rat, *Thallomys nigricaudatus* – were observed nesting in colonies in Acacia trees in the Gawib river channel. The health of the tree rat population is connected to that of the Acacia forest. Currently the mine cuts the subpopulation of the lower Gawib off from the upper Gawib, but this is not likely to have deleterious consequences on the upper population provided that the connection is eventually re-established after mine closure.
Namaqua rock mouse, *Micaelamys namaquensis* – lives in rock crevices or holes in trees and is expected to occur in the mountains and foothills of ML140, and probably also in the Acacia forest. They mostly eat seeds, but are not specialized as to the kind. They quickly adjust to conditions: individuals aestivate to save energy and water during harsh conditions, and populations can breed up quickly following favourable conditions (Withers, Louw & Henschel, 1980). They are not easily disturbed (except by habitat destruction), very adaptable to changing conditions, and readily colonize newly available space, such as rock piles left after mine closure.

Cape short-tailed gerbil, *Desmodillus auricularis* – are denizens of the open plains and can survive indefinitely on dry seeds. They will feed on fresh leaves and insects when available. They hoard seeds in side chambers of their otherwise simple burrows. Their burrows are often located on the open plains or into a hummock, with the entrance pushed closed with soil by day. They are therefore easily overlooked. Mining will represent loss of area until restored.

Setzer’s hairy-footed gerbil, *Gerbillurus setzeri* – establish social warrens on open plains. Grass can germinate at those places where these gerbils have disrupted the otherwise impenetrable desert pavement, and the vegetation circles of about 5 m diameter are typically the result of the past activities of Setzer’s hairy-footed gerbils. These nocturnal gerbils eat seeds and insects, and these denizens of the Namib gavel plains have the greatest urine concentration ability of all gerbils. There is potential for harnessing these ecosystem engineers and ecological pioneers for the restoration process.

Pygmy rock mouse, *Petromyscus collinus* – live in rock shelters in the mountains and koppies. They can be found on seemingly the most barren rocks, e.g. Schieferberg during dry years, and when it appears that no seeds are available. They can survive without fresh water and may feed on droppings of animals such as hyrax, rock rabbits, klipspringer or zebra, which feed elsewhere and defecate only partly digested matter in the mountains. Pygmy rock mice reproduce slowly and breed only once a year – we caught a pregnant female during early April in the current study. Populations tend to be stable and tenacious. These denizens of the rocky mountain massifs will only marginally be impacted by mining. Their hardiness may be a desirable characteristic when reintroducing life to sterile rock piles.

Bats – occur around LHU, but only one species, the long-tailed serotine bat, *Eptesicus hottentotus*, could be identified. Judging from the activity of bats, there are likely to be several species and these may include the flat-headed free-tailed bat, *Sauromys petrophilus*, Egyptian slit-faced bat, *Nycteris thebaica*, Geoffroy’s horseshoe bat, *Rhinolophus clivosus*, and Darling’s horseshoe bat, *Rhinolophus darlingi*. The concern with bats in a mining area is their roosting places, if these should, indeed, occur inside the mining area. Whereas the Egyptian slit-faced bat will readily use buildings, the other species require caves, or at least sufficiently large cavities to roost, sometimes going downwards. Roosting sites were not located in ML140 during the current study, but a thorough study would be required. Before any mountain slopes or koppies are disturbed, it will be important to find any roosts that may occur so as to avoid their destruction. A specialist must be consulted if it should be necessary to shift natural roosting sites of bats, i.e. how to compensate for the loss of a natural roost.

Suricat, *Suricata suricatta* – roam the open plains by day and shelter in warrens by night. They establish new warrens from time to time as their voracious foraging activities deplete local availability of arthropods and reptiles. The small pits left where they have dug up burrowing prey introduce small-scale heterogeneity into the otherwise hard substrate, which may enable or facilitate other digging animals, such as gerbils, to burrow even deeper or for different species of plants to germinate. Their assiduous digging activities of new warrens continuously establish new living space for a host of other species, which use burrows as retreats, but cannot dig their own. Suricats have huge home ranges and will avoid areas disturbed by mining. Their reintroduction should be encouraged in restoration for their roles as predators and diligent diggers to come into play in restoring a functional ecosystem.

Slender mongoose, *Galerella sanguinea* – were seen at several places in the upper Gawib and the edges of granite koppies. They seem to favour the lower-lying locations of the area, i.e. the valleys not hills, but
occur at low abundance. These diurnal predators eat insects, lizards, mice and birds. Slender mongooses avoid disturbance.

**Cape fox**, *Vulpes chama* – was seen in a shallow drainage line on the western plains. This omnivore favours open country. It is the most versatile and tenacious carnivore of all, and requires no water. They are vulnerable when breeding, and will carefully select safe den sites, a requirement that busy mining disrupts. Foxes will return when functional ecosystems have been restored.

**Black-backed jackal**, *Canis mesomelas* – occur in all habitats, and commonly shelter under overhangs or dense shrubs or Salvadoria hedges. They currently still frequent areas quite close to the mine and the current availability of artificial water as well as insects gathering at night in lit areas would enhance their presence. Except for loss of home range, and changes in food resources, jackals are unlikely to be disturbed by mining activities.

**Striped polecat**, *Ictonyx striatus* – is rarely seen, but its scats and digging activity for grubs on hillsides are evidence of its presence. They eat mostly insects, but also geckos and other vertebrates, hunting strictly at night. Disturbance will cause them to retreat further into the mountains, from where they will re-emerge after mining closure.

**Springbok**, *Antidorcas marsupialis* – is the most common ungulate and occurs throughout the Gawib river and on both adjacent plains. Resident herds disappear seasonally when they aggregate and migrate through the Namib-Naukluft Park in pursuit of the freshest grass, but they return later in the season. Although mining-related activities do not seem to perturb individuals and herds, they are now no longer able to move from west to east along the Gawib valley. This may affect the long-term use of western plains, but only temporarily, until the Gawib valley is restored.

**Klipspringer**, *Oreotragus oreotragus* – frequent all surrounding mountains and granite koppies, but vacate territories close to the mine. They come down from the mountains to feed in the washes or the Gawib channel away from the mine. Disturbance by mining-related activities will reduce the access by klipspringer of the relatively rich resources of the Gawib valley, which may lead to a temporary population decline to a lower level. Availability of vacant territories after mine closure will naturally restore this.

### 8.1.2 Regular Commuters

**Hartmann’s Mountain Zebra**, *Equus zebra hartmannae* – occur virtually throughout ML140. However, zebras do not reside in ML140 but frequently cross it, and for that purpose particularly the north-eastern flanks of the Schieferberg and the trans-Schieferberg canyon are critical (Figure 3). On the opposite side of the valley, the largest two watercourses of the Langer Heinrich Mountain (GTL4 & 5) is an important part of the corridor as well as the foothills of the Tinkas Mountain (Figure 3). Other trails that were used by zebra in the past, such as Reid wash (GTS1; Figure 3) are no longer favoured since mining-related activities commenced on the west side of the Gawib valley, although some zebra still cross from GTS1 onto the western gravel plain (PLW) and from there arc back to the lower Gawib. In the eastern part of ML140, i.e. the upper Gawib and Tinkas-Rocksculpture plains (Figure 3), there are no comparable zebra trails until outside the ML140 when one gets to the Tinkas canyon, and trails approaching from the Gawibberg located south of the eastern extremity of ML140 (Figure 3). Disturbance by mining-related activities of zebras where they cross the Gawib valley has the potential of disrupting part of the local sub-population of zebras with unknown repercussions for the zebra sub-population as a whole. Zebras are known to be animals of habit, and younger individuals will follow traditional knowledge of older herd members; disruption of the established routes may lead to loss of knowledge of this connection to the population. How zebra relate to current and future activities of LHU and how LHU could manage any possible impacts needs to be established in a dedicated study. Until better information is available, the precautionary principle must prevail, and great care be taken not to sever the movement corridors of zebra across the Gawib Valley and its flanking hills and canyons. Mining in the Gawib Valley should proceed with this in mind in such a way that a corridor across the valley is maintained. More detailed studies of zebra should help to improve the required planning.
Gemsbok, *Oryx gazella* – are currently less common than zebra in ML140, but use the same corridor. Before mining, herds of gemsbok would probably have moved up and down the Gawib valley. Significant gemsbok herds currently occur closer to the Swakop River as well as in the Tinkas area. Further south, the closest concentrations appear to be around Hotsas and Ganab. Gemsbok herds occasionally follow the same corridor through the Gawib valley that zebra use, but they do not depend on it. The difference is that gemsbok are denizens of the open plains and do not use traditional routes in the way zebra do. Gemsbok herds shift location across vast areas according to the availability of grazing, browse and water. Although herds cannot move up and down the Gawib valley as they used to do, the temporary disruption is not likely to have a big impact on the local population because gemsbok herds do not have a high degree of site fidelity. However, poaching is a much more serious threat to them. The well-maintained road of LHU down to the Swakop River inadvertently gives easy access and exit to poachers into the area, as a recent severe poaching event of gemsbok demonstrated (we found fresh evidence and reported this to MET). It is recommended to coordinate with MET concerning better control of access to this route.

Spotted hyaena, *Crocuta crocuta* – occasionally roam the area, judging from isolated droppings, signs of crushed bone and one track, they probably forage alone. Spotted hyaenas could have clans with dens further east at Tinkas, Onanis or Arisab, well within the home range of even a single clan. Availability of water is critical (Tilson & Henschel, 1986). These carnivores have been killed by farmers and the Namib population is under siege, especially as their clans, are so resident, albeit using huge territories. At ML140 they would have water, at least nearby in MLH or the vicinity of MTK, food in terms of large game, gemsbok and zebra, which they hunt (Tilson, von Blottnitz & Henschel, 1980), and relative safety from farmers and poachers. The broken landscape is, however, not good hunting ground for these predators that like to hunt on open ground. Judging from the relatively few prey carcass remains in ML140, this is a marginal area for spotted hyaenas, where a clan kills a gemsbok or zebra every week (Henschel & Tilson, 1988).

### 8.1.3 Occasional Transients

Aardvark, *Orycteropus afer* – dig for termites and ants along the border of the Tinkas Rocksulpture Plain. The presence of aardvark is significant as their deep and complex burrow systems are used by several other species of mammals (e.g. bats, warthog, porcupines, aardwolf) and reptiles (lizards and snakes). ML140 is not important for the local population. Ecosystem engineering by aardvark could be harnessed for restoration.

Cape porcupine, *Hystrix africaeaustralis* – roam the Gawib valley and adjacent hills where they dig up roots and lily bulbs, including at sites quite close to the mine plant and pits. They may ring-bark woody vegetation and affect their composition, although no evidence of this was seen in ML140. Foraging holes dug by porcupines enable different plant species to establish when seeds drop in and germinate in the broken soil layer, which may increase the biodiversity. There are signs of their shelters in the foothills, overhangs in calcrete-capped conglomerate hills, and granite koppies of ML140. The ability to move in and out of the Gawib valley and to obtain food from it is critical for the presence of porcupines this far west. However, ML140 is not thought to be critical for the porcupine population as such, as this is probably a “sink” area.

Chacma baboon, *Papio hamadryas* – are found in the Swakop River adjacent to LHU, and visit the Gawib spring. Although they currently do not occur on ML140, the new potential availability of open water in the form of the watering pond used for dust suppression would enable baboons to venture to LHU. Once they learn of this water, they may forage in areas that they would otherwise not have visited, and there is a potential for inducing conflict with people. The current partial fence will not suffice to keep out baboons, and in any case they climb over fences. The LHU reservoirs containing Swakop River water should be replaced with closed tanks to avoid discovery by baboons.

Reddish-grey Musk Shrew, *Crocidura cyanea* – live in dense litter, typical of ephemeral rivers. It is possible that a population from the Swakop River population extends up the Gawib channel and into its
tributaries. An owl pellet found in Reid wash contained shrew jaws, and this is the only shrew species known from the central Namib. LHU is located at the distribution boundary, where these shrews are rare and therefore special.

**Aardwolf, Proteles cristatus** – was seen on the plains of the Tinkas Rocksculptures. Aardwolf probably move in from the east to forage for termites and ants, and live for some time in dens in the ground, such as aardvark burrows, which they extend. Langer Heinrich is at the very edge of the distribution range of this species.

**Leopard, Panthera pardus** – have the potential to be found at LHU. It is most likely that individuals will travel, either via the Swakop River and along the flanks of MLH or via the Tinkas Mountain area where they would get water. However, typical types of prey such as duiker, steenbok, warthog and baboon, are rare or absent in ML140, klipspringer difficult to hunt, and springbok tend to stay in country that is too open for leopard to stalk in, so leopard encounters in the ML are likely to be rare.

**African wild cat, Felis sylvestris** – may possibly occur in areas with denser shelter of the Gawib river, its tributaries and the water-bearing mountains. Although there is much prey, the lack of water in ML140 may mean that although African wild cats occur nearby, they would not normally use ML140 (unless artificial water sources change this).

**Small-spotted genet, Genetta genetta** – may venture from the Swakop River up the Gawib riparian and would be closely associated with the dense vegetation in the Gawib channel. They could occur in the Acacia trees, but were not actually sighted.

**Bat-eared fox, Otocyon megalotis** – forage for insects in small groups on the plains, and may also occur in the Gawib valley, although they avoid human vicinity. Bat-eared foxes will avoid the close vicinity of the mine and return when it has quieted down. The lingering presence of these conspicuous insect-predators is an indication of a well-functioning ecosystem during restoration.

**Warthog, Phacochoerus africanus** – was seen running from a burrow in the upper Gawib and another warthog burrow was found in a drainage line of the eastern plains (PTR). It is not typical to see warthogs this far in the desert, and the above-average rains of the last two years appear to have enabled them to venture this far into the desert.

**Giraffe, Giraffa camelopardalis** – were recently released into the northeast section of the Namib-Naukluft Park and were seen near LHU by SHER staff. In pre-colonial times, giraffe probably frequented the Gawib valley and moved between it and the Swakop River.

**Kudu, Tragelaphus strepsiceros** – may occasionally move up the Gawib to LHU. They reportedly occur in the Swakop River opposite Langer Heinrich. This area is within their marginal range and habitat.

**Common duiker, Sylvicapra grimmia** – could occur in the Swakop River and may perhaps move up the Gawib or the Tinkas Rivers and could reach ML140. They require bushes for shelter and food.

**Steenbok, Raphicerus campestris** – was seen in the Swakop River opposite LHU. When the population should expand, it is possible that territories are also established along the lower Gawib.

### 8.2 Reptiles

It is estimated that ML140 contains 45 species of reptiles (Appendix B), of which 19 species are endemic to the Namib Desert or Namibia and ten species are of special conservation significance. The results of the reptile study that was commissioned as part of this baseline study reveals that the Damara tiger snake, *Telescopus* sp., is a new species, and another four species are about to get new names, when taxonomically separated from the species whose name they currently tentatively carry (these are Delalande's blind snake, *Rhinotyphlops lalandei*, Northern Plain Sand Lizard, *Pedioplanis cf. inornata*,...
Namibian Namaqua sand lizard, *Pedioplanis namaquensis quadrangularis*. Another special species is the Husab sand lizard, *Pedioplanis husabensis*, which has a very small distribution range confined to the core of the Uranium Province. The Namib ghost gecko, *Pachydactylus kochi*, is a rare species, and the LHU record extends the known distribution range of this species, which can also be said for the records of the spotted desert lizard, *Meroles suborbitalis*, the Damara tiger snake and Delalande’s blind snake.

Three reptile species are highlighted as potentially threatened by pet trade, namely the Namaqua chameleon, *Chamaeleon namaquensis*, leopard tortoise, *Stigmochelys pardalis*, and rock monitor, *Varanus albigularis*.

### 8.2.1 Snakes

Snakes – 15 species were either seen, reported or expected at LHU, which represents a high diversity, for which the Namib Desert is known. The only common snake is the horned adder, *Bitis caudalis*, a cryptic ambush hunter. SHER staff recorded the following species, which I tentatively identified from photographs: Delalande’s blind snake, *Rhinotyphlops lalandei*, Namibian worm snake, *Leptotyphlops occidentalis*, Damara worm snake, *Leptotyphlops labialis*, brown house snake, *Lamprophis fuliginosus*, Namibian wolf snake, *Lycophidion namibianum*, western keeled snake, *Pythonodipsas carinatus*, dwarf beaked snake, *Dipsina multimaculata*, western whip snake, *Psammophis trigrammus*, Namib sand snake, *Psammophis namibensis*, rhombic egg-eater, *Dasypeltis scabra*, coral snake, *Aspidelaps lubricus*, and Damara tiger snake, *Telescopus* nov.sp. Two other species of snake could occur at LHU, namely, the zebra snake, *Naja nigricincta*, and the puff adder, *Bitis arietans*, both being more typical of the Swakop River, but may come to LHU up the Gawib. Given that many snakes are brought to the attention of SHER staff by mine workers, the current record of snakes seems to over-represent those habitats where most mining activity occurs, and it is expected that snakes are probably found in higher numbers away from the active mining sites. The high diversity of snakes in ML140 indicates that, despite mining, there appears to be a good availability of a range of prey for snakes. Ongoing records of all snakes that are seen should be kept as this is the best way to accumulate better information on snakes to inform future planning, i.e. snake diversity can be a good indicator. The following data should be recorded: date, snake identity, GPS location of first sighting and of release site, habitat, notes on exact surroundings, name of first observer, name of person who recorded and photographed it, any other observations.

Dangerous snakes – The only snakes venomous to humans recorded at LHU are the coral snake and the horned adder, neither of them extremely dangerous (i.e. not life-threatening). Two other snakes that could occur at LHU, but have not been recorded, the zebra snake and puff adder, are far more dangerous. Although other snakes are not dangerous, some mimic dangerous snakes, e.g. the keeled snake and beaked snake mimic the horned adder. All snakes should be treated with care and removed for the snake’s own safety and released away from the mine in habitats that are viable for them. Since many snakes are caught at the mine, information on typical habitats can, for example, be made available on pamphlets so as to increase awareness and provide information on their management. If the habitat is unknown, a location with rocks and shrubs in the vicinity would be a first approximation of what snakes captured in the Gawib valley may require when released. Different places of release should be used over time, so that snakes are not released into overcrowded territories where they may come into conflict with each other.

**Damara tiger snake**, *Telescopus* nov.sp. – was recorded at least three times at LHU, and is a species yet to be officially described and named. The LHU observations are the southern-most records of this snake (Conradie, 2009). It is thought to be rare and endemic to the Central Namibia, and is data-deficient. As such, it should at this stage be regarded as being a threatened species. The LHU records were made at the mine plant, indicating that these snakes were in the valley or Gawib River, or the adjacent rocky cliffs. This species is thought to be rupicolous (living among rocks). SHER staff should keep detailed records of where exactly and in which kind of microhabitat these snakes were first located, as this information would help inform the description of the species. A detailed study is recommended to confirm this snake’s identity.

**Delalande’s blind snake**, *Rhinotyphlops lalandei* – was recorded once in ML140, in the Gawib Valley. The Namibian population of this snake is very localized and disjunctive, far from the main distribution area of
this species in the eastern half of southern Africa. According to Prof Bill Branch (Bayworld Museum, Port Elizabeth, South Africa), the Namibian *R. lalandei* may turn out to be different from the ones occurring in South Africa, Botswana and Zimbabwe. Blind snakes primarily feed on termites and burrow into the ground. A detailed study should be conducted to advise on the status of this species. It is suggested that SHER staff take tissue samples from specimens when found again according to the methods recommended by the reptile specialist (Conradie, 2009). Although these termite-eating snakes are probably not rare, given that termites are abundant in the Gawib Valley and some other habitats (Irish, 2009), but these snakes are seldom seen by people as they are small, cryptic and fossorial (burrowing).

### 8.2.2 Skinks

Skinks – Six species of these diurnal reptiles occur at LHU. Habitat use differs between species. The wedge-snouted skink, *Trachylepis acutilabris* is the most common and most ubiquitous skink on ML140, particularly associated with perennial vegetation and their sandy hummocks into which they burrow. Wedge-snouted skinks make themselves conspicuous by raising their tails when standing, perhaps as a territorial signal. Western rock skink, *T. hoesi*, lives in rock crevices and is commonly found on the mountains and koppies. Koppie skinks, *T. sulcata*, also live on koppies and rocky outcrops on mountains, but forage more in the open than the other rock-living skinks. Koppie skinks are fairly common in such habitats elsewhere in the Central Namib, but were only seen once on ML140. Western three-striped skink, *T. occidentalis*, is commonly found in sandy areas of the Gawib valley and fringes of granite koppies at places with perennial vegetation. The western variegated skink, *T. variegata*, is similar in habitat use, but this smaller skink is associated more with stony areas close to perennial vegetation. Variegated skinks habituate easily and also live around buildings. Namibian tree skinks, *T. spilogaster*, live in the Acacia trees of the Gawib. Although none of these skinks are of special conservation significance, as a group they are the vertebrates most commonly seen, especially because they are diurnal. Their high diversity, six species of one genus, in such a small area, can serve as a potentially valuable tool to sensitize mining staff to the diversity of life in the Namib. These insect-eating skinks will quickly re-enter vacated suitable habitat post-mining provided there is food and shelter and should be seen as pioneers for restoration.

Unidentified skink – was collected among shrubs at the boundary of a granite koppie. Although this large individual could be closely examined, it could not be identified by an expert (Conradie, pers.comm.), and further laboratory work including DNA analysis is being conducted. In the meantime this unidentified skink should be treated as if it is a new, rare species. Boundary zones of granite koppies should be managed accordingly, following the precautionary principle.

### 8.2.3 Lizards

Spotted desert lizard, *Meroles suborbitalis* – was observed once at a shrub in a shallow wash on the western gravel plain, its typical habitat. This lizard has a wide distribution in southern Namibia and the Karoo, but its taxonomy is subject to revision in the Central Namib, where it is suspected that there may be several different species currently under the same name (Griffin, 2003). The precautionary principle should be upheld and the destruction of the habitat of the ML140 population should be avoided until it has been established how they are connected to the population of *M. suborbitalis* in the Tumas basin.

Short-headed sand lizard, *Pedioplanis breviceps* – is common on the hard, open plains west and east of LHU. Conradie (2009) also found them on them in the Gawib valley, the upper Gawib and the Schieferberg washes and slopes. In the heat of the day, these light-coloured lizards can be seen standing on top of stones. This species is endemic to the northern half of the Namib Desert. Mining will cause loss of space for an otherwise secure population.

Namaqua sand lizard, *Pedioplanis namaquensis quadrangularis* – was captured on the isolated sandy patch near LHU Westgate. This species is known to be associated with sand around vegetation, and may therefore also occur at hummocks in the Gawib valley. ML140 is the eastern boundary of this species. This species is subject to taxonomic revision and the Namibian subspecies will likely be elevated to species level as *P. quadrangularis* (Makokha *et al.*, 2007; Conradie, 2009), but this lizard is so widespread
that the revision is unlikely to change the conservation status even though this lizard is not common in ML140.

Husab sand lizard, *Pedioplanis husabensis* – has a small distribution range (the uranium province), and ML140 is at the edge of this (Berger-Dell’mour & Mayer, 1989). Recent studies have confirmed that *P. husabensis* is quite distinct and diverged from other sand lizards some 8 million years ago (Makokha et al, 2007). The Husab sand lizard is a potentially threatened species (data deficient), exasperated by the number of uranium mines occurring or arising in its range. It has a small distribution range, the second smallest known for any sand lizard. They have been observed at LHU in the past - Berger-Dell’mour & Mayer (1989) collected *P. husabensis* at Langer Heinrich and used these specimens for their description of the species. The diet of this species includes the young of other lizards (Branch, 1998).

A specialist study was conducted as part of this baseline (Conradie, 2009) so as to improve our knowledge of this species in ML140. Husab sand lizards occur on and around quartzite ridges on the Langer Heinrich Mountain, Schieferberg, Tinkas Mountain as well as on granite outcrops, favouring broken rocky terrain, including rocky outcrops on a sandy base such as seen on the Westgate sand patch. Husab sand lizards were found at several locations of rocky terrain inside and beyond ML140, and the abundance of juveniles in April 2009 around quartzite ridges of the Schieferberg following the rains of this season indicated that the population is thriving around these quartzite nodes, from where individuals venture across open habitat to forage. Inside ML140, Husab sand lizards were recorded in eight habitats, which did not include the Gawib valley where the mine pits are located (Appendix B; Figure 3). Conradie (2009) reported seeing *P. husabensis* on a rock dump of MSB2, but in general it was observed that these lizards tended to avoid disturbed areas, and they are quick to escape given a chance. Given that the places of highest abundance of these lizards, particularly of juveniles, was around the light-coloured quartzite ridges on the dark schist of Schieferberg (e.g. on the boundary of MSB1 & 2 and MSB6) and of Tinkas Mountain, these areas are key to the conservation of this species in ML140. Mining-related activities should avoid damaging those locations. In the case of the proposed tailings facilities in MSB2, the development should avoid, if possible, the 100-m long and 20-m wide quartzite ridge that marks the boundary between MSB1 and MSB2 at S22.81883 E15.30981 (Figure 3), as this is an area where Husab sand lizards are abundant. Likewise, developments at other sites during the life of mine should avoid damaging quartzite and granite ridges, as well as boundary zones of tens of metres around these.

Northern Plain Sand Lizard, *Pedioplanis cf. inornata* – is the northern form of the plain sand lizard and awaits taxonomic revision for the species to be separated (Berger-Dell’mour & Mayer, 1989; Makokha et al, 2007; Conradie, 2009). It is thought that this species is near the southern limit of its range in the vicinity of Langer Heinrich, but the range has yet to be fully determined during the course of the species description. While this revision is in process, the precautionary principle should be upheld, and the species be regarded as of conservation significance. During the current survey, it was not always possible to clearly distinguish this species from the Husab sand lizard seen from a distance (the configuration and size of scales around the ears and eyes are diagnostic characteristics, but this requires handling or clear photographs, difficult to achieve with fast-moving animals). For that reason the potential habitat occurrence of this species may appear to be similar as that of the Husab sand lizard in the Table of Appendix B. Positively identified individuals of this species were found at a quartzite ridge on MTK (Conradie, 2009; pers.comm.), and in the westernmost Schieferberg wash GTS1 (pers.obs.), both being habitats of high biodiversity sensitivity for several reasons (Figure 3). The ongoing DNA analyses of collected specimens that are part of the current investigation (Conradie, 2009) should refine our knowledge of this species at LHU and beyond, in order to understand its distribution and habitat requirements.

Dwarf plated lizard, *Cordylosaurus subtesselatus* – was observed at several locations, including the Westgate sandy patch. Other places are granite koppies and the small quartzite patches on the Tinkas Mountain foothills. It is associated with shrubs along rocky ridges. The presence of these pretty-looking uncommon lizards at “shrubs along rocky ridges” adds another reason for taking care to preserve these microhabitats wherever possible.
8.2.4 Geckos

Giant ground gecko, *Chondrodactylus angulifer namibensis* – come into the open early at night and often stand on roads, where they are killed. They spend the day in freshly dug burrows. Driving by night is likely to have the most serious impacts on the population of this impressive gecko.

Festive gecko, *Narudasia festiva* – this crepuscular species is expected on granite koppies. It feeds on ants and flies. It is endemic to central and southern Namibia. This pretty animal is one of many attractions for tourists along the Rocksculpture trail.

Thick-toed geckos, *Pachydactylus* – on LHU comprise six nocturnal species. The record of the rare Namib ghost gecko, *Pachydactylus kochi*, by the SHER department is a special sighting, as this species has a small distribution range that is more coastal. The LHU record is a new record beyond the known distribution range. Ghost geckos typically occur on sandy substrates such as occur in places of the central Gawib valley and the upper Gawib. A Namib variable gecko, *Pachydactylus punctatus*, was seen under an Acacia tree. Other thick-toed geckos such as Namibian rough scaled gecko, *P.rugosus*, velvety thick-toed gecko, *P.bicolor*, button-scale gecko, *P.turneri*, and Weber's gecko, *P.weberi* are expected to occur on rocky mountains and granite koppies where they shelter under flaky slabs and are difficult to see. Keeping the granite koppies and the immediate vicinity around these koppies undisturbed would go a long way to maintaining the high diversity of thick-toed geckos on ML140.

Common barking gecko, *Ptenopus garrulous* – are very abundant in all open habitats of LHU. They were seen on the roads of LHU at night and several road kills were recorded. This species is wide-spread and the population is very dense, so that the impact on the population is probably negligible. Barking geckos dig shallow burrows that serve as retreats for insects and spiders when abandoned. Their audible and visible activities in evenings are ready signs of established life and ecological functioning, and could be used as indicator during the ecological restoration process.

Namib day geckos, *Rhoptropus* – are represented by three species. The Barnard's Namib day gecko, *R.barnardi*, is most widespread, common especially on the schists, and less common on quartzite. *Rhoptropus bradfieldi* is common on the granite koppies, and also seen on quartzite. *Rhoptropus boultoni* was not seen, but is expected to occur on trees in the Gawib and its tributaries. Where mining disturbs rocky habitats this would be a minor loss of terrain for the extensive populations in the mountains surrounding LHU.

8.2.5 Other Reptiles

Agama: Western rock agama, *Agama anchietae*, are widely distributed on ML140 and were seen or are expected to occur in nearly every habitat. They are cryptic and occur in the open on rocks or stones by day, while at night they seek shelter in rock crevices or tree hollows. Judging from the young seen during the current survey, the population is growing following the two exceptional rainy seasons. Namibian rock agama, *Agama planiceps* were seen in groups on granite koppies where they hunt insects and are hunted by raptors and small carnivores. These colourful diurnal reptiles are attractive for park tourists to see. *A.anchietae* are expected to quickly re-colonise areas post-mining, whereas *A.planiceps* may need to be re-introduced where colonies have been destroyed. Since this is difficult, it is advisable to avoid destroying or disturbing such colonies in the granite koppies.

Namaqua chameleon, *Chamaeleon namaquensis* – are relatively common on ML140 in all open habitats, i.e. the plains, upper Gawib and the Gawib Valley. This species is listed on Appendix II or CITES due to the potential threat of collecting for trade as pets. During the heat of the day, Namaqua chameleons shelter either in the canopy of plants, or climb on top of high stones to get above the heat. Viable populations of chameleons, which can be readily detected given the search image, are good indicators of ecosystem function. Furthermore, chameleons are considered to be interesting by many people and can serve as important tools for environmental awareness raising for mining staff.
Kalahari round-headed worm lizard, *Zygaspis quadrifrons* – feed on small insects, such as termites, and live under slabs of stones, which are typical in much of the Gawib valley and on the gradual slopes of schist hills. These worm lizards have not yet been observed in ML140, but are expected.

**Leopard tortoise**, *Stigmochelys pardalis* – could come to this part of the Namib via the Swakop River and then go up the Tinkas or Gawib. SHER staff reported seeing a tortoise along the Tinkas River just outside ML140. This is at the extreme west end of the distribution boundary. Leopard tortoises are listed on Appendix II of CITES due to the threat of poaching and pet trade.

**Rock monitor**, *Varanus albigularis* – or white-throated monitor, is likely to occur in the Swakop River and could move up the Gawib or Tinkas and from there it could reach ML140. This species has been overexploited and is therefore classified as vulnerable, and listed in the CITES Appendix II.

8.3 **Frogs**

**Marbled rubber frog**, *Phrynomantis annectens* - survives in rock crevices between rare heavy rainfalls required for it to reproduce in ephemeral pools after rainfalls. It is not known whether marbled rubber frogs actually do occur in ML140, but they are known to occur at ephemeral pools elsewhere in the Central Namib. These frogs are very rarely seen and great care should be taken especially by vehicles driving at night on roads across the plains after rain. Elsewhere in the Namib I have seen these rare frogs moving between ephemeral pools at night during periods when the ground is wet. Frogs are only part of the unique set of species associated with ephemeral pools. Special recommendations on the management of such pools are made in the habitat section.

**Cryptic sand frog**, *Tomopterna cryptotis* – can also aestivate near pools, but in this case they require sand to dig into. In ML140, one would expect Cryptic sand frogs to occur in the deeper, longer-lasting pools in the quartzites of Langer Heinrich Mountain and Tinkas Mountain. They could also be found in pools of the tributaries or lower Gawib (e.g. Gawib spring after a flood). These pools are located outside ML140, and provided they are not disturbed by people wandering in the mountains, these frogs and their pools should be safe throughout the life of mine.

8.4 **Birds**

The number of bird species at LHU is expected to be no less than at Gobabeb, i.e. 200 (Henschel et al. 2006). It is highly recommended that LHU periodically monitors bird populations, because continuous series of data over the years should be valuable to detect future trends in bird abundance and diversity, but surveys should be well-planned (advised by ornithologists conducting surveys elsewhere) in order to be meaningful and analyzable.

Many resident birds, including the conspicuous ostriches, occur on ML140 in places not subject to active disturbance at the time and move away from mining impacts. Critical for birds are their nesting requirements; this may be very specific, taking into consideration microclimatic conditions and protection from predators and other hazards. While nesting, birds cannot migrate without losing their brood. Trees and cliffs are obvious retreats for nesting, but many birds nest in shrubs or small cavities in rocks, and many species, such as ostrich, korhaan and sandgrouse, do it right in the open. Some larks nest under grass tufts, where their clutches or broods are easily overlooked. Especially during the main breeding period – for many Namib birds this is December-March – it should be avoided to drive on seldom-traveled vehicle tracks or to drive new tracks that could damage broods. Many nocturnal birds sit on roads at night as they can more easily see predators in such open stretches, but they become mesmerized by vehicle’s headlights and are at risk of being run over by night traffic. Vehicles should, whenever possible, avoid driving through the Namib-Naukluft Park at night.

A special bird that has already lost significant breeding space is the lappet-faced vulture, *Torgos tracheliotus*, which nests in Acacia trees and used to nest in the Gawib River. These vultures do not tolerate frequent disturbance when nesting. The population of this species in the Namib-Naukluft Park is of special significance and is being observed by the Namibian Vulture Study Group, and it is advisable to consult the chairperson, Mr Peter Bridgeford of Walvis Bay if advice is required. Some vultures nest near
ML140, but far away enough not to be disturbed, for instance in a few trees located west and others south of the Schieferberg. When the Gawib becomes quiet again after mining closure, vultures are expected to return provided that the Acacia trees survive and provided the vulture population has sustained the current temporary loss of Gawib nesting sites.

Bird activities have numerous kinds of effects on their environment and on other species. The following descriptions are only a few examples that illustrate the numerous ways in which birds are an integral part of the ecology of the LHU area. Many birds are important predators of other vertebrates and invertebrates and may affect the behaviour, ecology and populations of the latter in numerous ways. Birds are important granivores, and their consumption of plant material or the harvesting for other purposes, such as nest material, can have significant effects on plants occurring in ML140. The same can be said for the effect of birds on arthropod communities. The actions of birds can have facilitation effects. A nest built by one bird or pair, can subsequently be used by other birds of the same or different species or by a host of other animals ranging from arthropods to tree rats and snakes who make use of the protection of the close-knit material. This group of vertebrates has a propensity to respond opportunistically to temporary fluctuations in resources in the desert, especially primary production following local rains or lack thereof, and bird numbers, at least of some species, can skyrocket or plummet at any given site. These quick changes in numbers of local consumers have important ecological consequences. Birds are important vectors in and out of ML140. While the ecological significance of seed transport between habitats and regions is one primary result that should not be underestimated – many plants gear their seeds specifically towards using this transport – birds may also inadvertently transport materials on the outside of their bodies, particularly their feet. This is how, for instance, eggs of aquatic animals, including eggs of frogs, if they survive, could first get to isolated water pools in rocks.

It is important to note that birds can transport pollution (let alone be affected by it). A bird that has, for instance drank, waded through or bathed in tailings or chemicals elsewhere at the mine plant may fly these minerals or other chemicals to wherever it goes next, which may be a tourist’s breakfast at Bloedkoppie or the wetlands in the Swakop Mouth or Walvis Lagoon. Water birds like flamingos, pelicans and moorhens that have been recorded by SHER staff wading through the tailings dam indicate that the above-mentioned wetland exchange of minerals is already in process. Given that water birds and other birds find their way to LHU en-transit, some of them may be travelling inland, perhaps reaching the water reservoirs of Windhoek. The point here is to note that the question of pollution at LHU is not necessarily a local phenomenon, affecting LHU residents, but can also have outreaching implications. Although water is a primary attraction, birds have a knack of getting into many different places, for instance in pursuit of spiders hidden in some nooks or crannies of open storerooms, and they may there be exposed to any materials of the mine that are not scrupulously rendered completely inaccessible to them.

The open water reservoirs that are filled with Swakop River water attract many birds. Besides water in the reservoir itself, the many puddles of water splashed around the water tankers at the two water-filling stations (one on the ML at the end of the pipe with Swakop River water, the other west of the ML along the private road of LHU) draw birds to these convenient drinking places. This increase in the local density of birds can, however, have many consequences just as any artificial watering places have. These subsidized birds may deplete food resources in the surrounding area to the detriment of the prey species. Attracting birds with water to the mine increases the chances of conflict between them and people/mining processes. While water sources are on the one hand to be considered to be invaluable for desert animals, artificial water points without any ecological basis can be detrimental. Enclosing these reservoirs and ensuring less wasteful filling of water tankers would help to address this issue. Likewise, eliminating water of the tailings is apparently being planned in future. It is recommended that the current tailings dam should be fenced on all sides and bird deterrent devices should be activated.

9 ML140 HABITATS AND THEIR VERTEBRATE COMMUNITIES

ML140 comprises a mosaic of different habitats. Management considerations need to take special features of each habitat into consideration. More than that, the different pieces of the mosaic need to be seen in relation to each other, as the features of one habitat affect the characteristics of another.
Although this study recognises separate habitats, these are not discrete, and often the boundary between two habitats is a critical feature.

Disturbance, as by mining and mining-related activities, is a highly complex phenomenon. It does not merely reduce living space for animals, where animals merely avoid the affected area and go on living elsewhere. It may affect a certain critical component of their life, such as changing their ability to access a certain resource in the area.

Two contrasting examples illustrate this principle. Destruction of a single cave used by bats may be deleterious to many thousands of bats of a species that normally roams the entire ML140. It is therefore important to know where that cave is and to protect the ability of bats to continue to use it. Another example are Hartmann’s mountain zebra, which periodically move from their principal grazing grounds to water, and they do so along particular routes defined by topographic features and lack of disturbance. If these particular routes are blocked in a comparatively small area (such as ML140), this can potentially affect a significant proportion of the local zebra population.

In this section, habitats are described in terms of their location, physical features, ecological conditions, vertebrate diversity, threats and restoration potential. The biodiversity sensitivity rating applied for each habitat is an index that was derived based on the occurrence or not of sensitive features described under the headings “ecological conditions”, “vertebrate diversity”, “threats” and “restoration potential”. The rating given followed the conditions described in section 7.8.

A map of locations of habitats is shown in Figure 3, and a sensitivity map in Figure 4. How habitats and sensitivity relate spatially to the mine infrastructure is shown in Figure 5.
9.1 Gawib Valley Floor (GVF)

**Location:** It stretches along the middle half of the length of ML140 from the MLH-Witpoort gravel plain (PLW) in the west to the granite koppies in the east (Figure 3).

**Physical:** 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.

**Ecological conditions:**
- a) The Gawib valley is the most important connection between most of the habitats in the ML140 area;
- b) 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;
- c) Availability of refuge and food for small vertebrates.

**Vertebrate diversity:**
- a) High diversity: at least 18 mammals, 19 reptiles, and many birds;
- b) Blind snake species of possible special conservation significance;
- c) Species present regularly change over time due to connectivity with other habitats;
- d) All trophic levels are well represented.

**Threats:**
- a) Much of this area is or will be destroyed by mining, tailings or waste rock dumps;
- b) Loss of topsoil and of elements of the above-mentioned heterogeneity;
- c) Disruption of connectivity affects many species and many adjacent habitats.

**Restoration Potential:**
- a) Initial rehabilitation will be relatively straightforward, given that the current soil is not well developed and the ground relatively flat;
- b) Heterogeneity is more difficult to restore, and should include re-establishment of dwarf shrubs and sandy patches on generally stony ground;
- c) This is a
generalist habitat and reintroduction of species for repopulation should be possible; d) 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).

Sensitivity: Sensitive (2) site should not be permanently damaged and should be used in such a way that ecological function can be restored.

9.2 Gawib Channel Acacia-forest (GCA)

Location: This is the lowest part of the Gawib valley. 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.

Physical: This channel is occasionally flooded following local rains in the eastern half of the Schieferberg and on the plains south of it. GCA 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.

Ecological conditions: a) Occasional floods water trees and transport seeds and sediments; b) Productivity is highest of all habitats, and besides woody vegetation there is also a lot of perennial grass; c) 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; d) Linear connectivity for movements along the Gawib.

Vertebrate diversity: a) Highest number of species of mammals (23), reptiles (21) and birds, likely that not all species were recorded; b) Expansion and contraction of populations from the Swakop River changes biodiversity over time.

Threats: a) Channel blocked and changes in surface hydrology will change vegetation and substrate dynamics; b) Disturbance and pollution by mining; c) Destruction of perennial vegetation, especially large and complex Acacia trees represents critical habitat loss; d) Loss of ground water drained by mining causing trees to die; e) Disruption of connectivity limits mobility and range expansion and contraction of animals.

Restoration Potential: a) 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; b) Animals will return to this resource-rich habitat when the disturbance is gone and blockages of the river have been removed.

Sensitivity: Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed.

9.3 Upper Gawib River (GRU)

Location: Starts at the Gawibberg east of Bloedkoppie (outside ML140) and continues to the confluence with GCA towards the middle of ML140 at the end of the south-west reaches of Tinkas Mountain.

Physical: 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, PTR Plains of Tinkas Rocksculptures, which is part of the Tinkas sub-basin.

Ecological conditions: a) Perennial grasses and shrubs and a sparse scattering of Acacia trees of the upper Gawib provide food and shelter even in dry years; b) Large hummocks of sand have accumulated around shrubs, which mammals and reptiles dig into; c) Boundary areas to granite koppies are particularly productive.

Vertebrate diversity: a) High numbers of species of mammals (22) and moderate numbers of reptiles (13); b) Highest densities of small mammals of all habitats around vegetation hummocks; c) Rich boundary zone with granite koppies enhances biodiversity of both habitats.

Threats: a) Disturbance and pollution by mining; b) Removal of hummocks; c) Disturbance of boundary zones; d) Loss of connectivity upstream-downstream for small vertebrates.

Restoration Potential: a) Sandy substrate is straightforward to rehabilitate; b) It takes decades to re-grow hummock-forming dwarf shrubs and their destruction should be avoided wherever possible; c) Boundary zones to granite koppies can be cleared and will resume hydrological and ecological functioning.
9.4 Lower Gawib River (GRL)

Location: This is the continuation of the Gawib channel from the SW corner of Langer Heinrich Mountain downstream in a north-westerly direction out of the ML140.

Physical: Its relatively narrow channel forms an unbroken connection of coarse sandy substrate, shrubs and trees from LHU to the Swakop River.

Ecological conditions: a) Connectivity: some vertebrates that would be more typical of the Swakop riverbed can use this relatively sheltered corridor to get from the Swakop River to LHU; b) Availability of natural water; c) See GCA.

Vertebrate diversity: a) Many mammal species (19), moderate numbers of reptiles (12), many birds; b) Expansion and contraction of populations from the Swakop River changes biodiversity over time.

Threats: a) Channel blocked and changes in surface hydrology will change vegetation and substrate dynamics; b) Upstream threats in GCA will impact GRL.

Restoration Potential: Will restore naturally when the upstream GCA is restored.

Sensitivity: Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed.

9.5 Gawib Tributary #1 coming from Langer Heinrich Mountain (GTL1)

Location: West-most of five prominent washes that drain MLH into GCA, western boundary of FQB.

Physical: A steep, broken and relatively shallow rock-lined drainage line across the foot of MLH.

Ecological conditions: a) Availability of shade and other shelter along the relatively more productive canyon floor; b) Potential of water pools in upper section; c) Broken rock banks shelter animals that forage in the open channel of GCA.

Vertebrate diversity: a) High numbers of species of mammals (22) and reptiles (21), birds particularly attracted to water; b) GTL1 is important source of biodiversity for MLH and GVF both of resident animals as well as migrants.

Threats: Blockage of the mouth areas of washes blocks mountain-valley connectivity for animals.

Restoration Potential: Opening blocked mouth of wash will restore the main functions.

Sensitivity: Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.6 Gawib Tributary #2 coming from Langer Heinrich Mountain (GTL2)

Location: Second from west of five prominent washes that drain MLH into GCA, eastern boundary of FQB.

Physical: A steep, broken and relatively shallow rock-lined drainage line across the foot of MLH.

Ecological conditions: a) Availability of shade and other shelter along the relatively more productive canyon floor; b) Potential of water pools in upper section; c) Broken rock banks shelter animals that forage in the open channel.

Vertebrate diversity: a) High numbers of species of mammals (22) and reptiles (21), birds particularly attracted to water; b) GTL2 is important source of biodiversity for MLH and GVF both of resident animals as well as migrants.

Threats: Blockage of the mouth areas of washes blocks mountain-valley connectivity for animals.

Restoration Potential: Opening blocked mouth of wash will restore the main functions.

Sensitivity: Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.7 Gawib Tributary #3 coming from Langer Heinrich Mountain (GTL3)

Location: Middle of five prominent washes that drain MLH into GCA, forming eastern boundary of FCD1 and western boundary of MTK.

Physical: This is the steepest of all GTL washes, forming a small canyon with rocky banks, and deep water cisterns.
Ecological conditions: a) Availability of shade and other shelter along the relatively more productive canyon floor; b) Water pools that hold water for a long time after rain and are accessible to animals; c) Broken rock banks shelter animals that forage in the open channel.
Vertebrate diversity: a) High numbers of species of mammals (22) and reptiles (21), birds particularly attracted to water; b) GTL3 is an important source of biodiversity for MLH and GVF both of resident animals as well as migrants.
Threats: a) Blockage of the mouth areas of washes blocks local and long-distance connectivity; b) Proximity and ease of access by people could result in poaching and vandalism.
Restoration Potential: Opening blocked mouths of washes will restore the main functions.
Sensitivity: Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.8 Gawib Tributary #4 coming from Langer Heinrich Mountain (GTL4)

Location: Second from east of five prominent washes that drain MLH and the lower MTK into GCA, eastern boundary of FCD2 near the middle of the Gawib Valley.
Physical: A sandy channel with rocky banks that form a small canyon. Side channels contain sheltered water holes.
Ecological conditions: a) Availability of shade and other shelter along the relatively more productive canyon floor; b) Corridor for game into/from MLH, particularly zebra; c) Water pools that hold water for a long time after rain are accessible to animals; d) Broken rock banks shelter animals that forage in the open channel.
Vertebrate diversity: a) High numbers of species of mammals (22) and reptiles (21), birds particularly attracted to water; b) GTL4 wash is important sources of biodiversity for MLH and GVF both of resident animals as well as migrants.
Threats: a) Blockage of the GTL4 blocks local and long-distance connectivity; b) Proximity and ease of access by people could result in poaching and vandalism.
Restoration Potential: a) Opening blocked mouth of GTL4 will restore connectivity; b) Game corridor can resume once it is opened and zebras have learnt about this again.
Sensitivity: Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.9 Gawib Tributary #5 coming from Langer Heinrich Mountain (GTL5)

Location: East-most of five prominent washes that drain MLH and the lower MTK into GCA, located off the north-eastern corner of Gawib Valley.
Physical: A very broad, open drainage with gradually sloping stony banks that continue into the MTK hills.
Ecological conditions: a) Channel relatively more productive than adjacent areas; b) Important corridor for game, especially zebra, through the Tinkas Mountain.
Vertebrate diversity: a) High numbers of species of mammals (22) and reptiles (21), birds particularly attracted to water; b) GTL5 is important source of biodiversity for MTK and GVF both of resident animals as well as migrants.
Threats: a) Blockage of the mouth area of GTL5 blocks local and long-distance connectivity; b) Proximity and ease of access by people could result in poaching and vandalism.
Restoration Potential: Opening blocked mouths of washes will restore the main functions.
Sensitivity: Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.10 Gawib Tributary #1 coming from the Schieferberg (GTS1)

Location: West-most of five prominent washes that drain MSB, crossing the western Gawib Valley (tentatively called Reid Wash by LHU staff).
Physical: This wash comes down from the highest peak of MSB. It has confined banks in the mountain, and the channel widens as the wash enters and crosses the Gawib Valley. The flanks slope gently.
Ecological conditions: a) Connectivity: GTS1 used to be an important game corridor from Schieferberg into the Gawib valley; b) Availability of food, shade and other shelter along the relatively more productive
canyon floor, with numerous shrubs and hummocks; c) Broken rock banks shelter animals that forage in the open channel.

**Vertebrate diversity:** a) High diversity of mammals (21) and reptiles (21); b) At least four reptile species of special conservation significance were recorded, including the Husab sand lizard, the Northern form of the *Pedioplanis cf. inornata* (this was one of two sites where this species was recorded), and *P. namaquensis quadrangularis*, and the tiger snake is expected to occur here; c) Contains species from adjacent habitats GVF and MSB; d) GTS1 and its adjacent flanks is part of an important corridor for zebra (currently disturbed).

**Threats:** a) Blockage of GTS1 prevents local and long-distance connectivity; b) If tailings are placed across GTS1, this wash and its biodiversity will be permanently destroyed, and several reptile species of special conservation significance will suffer population reductions, for two species this being one of the few habitats where they were recorded.

**Restoration Potential:** a) Opening blockage of GTS1 will restore connectivity; b) Restoring productivity will take decades; c) Undertake studies of the vulnerable species to determine the significance of population losses and plan possible compensation.

**Sensitivity:** Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken. The flanks (MSB1) are part of this most sensitive zone up to and including a quartzite ridge located at S22.81883 E15.30981.

### 9.11 Gawib Tributary #2 coming from the Schieferberg (GTS2)

**Location:** Second from west of five prominent washes that drain MSB, entering GVF next to Westgate.

**Physical:** This wash is narrow, shallow and barely vegetated, and is relatively short in length.

**Ecological conditions:** a) Connectivity: GTS2 used to be part of a much-frequented game corridor from Schieferberg into the Gawib valley (currently completely dysfunctional due to disturbance); b) Broken rock banks shelter animals that forage in the open channel.

**Vertebrate diversity:** a) High diversity of mammals (21) and reptiles (21); b) Three reptile species of special conservation significance; c) Contains species from adjacent habitats GVF, MSB, and SPW; d) passes isolated sandy patch and is main source of the species that get to this patch; e) GTS2 was part of a corridor for zebra (currently disturbed), but less important than GTS1,4&5.

**Threats:** Disturbance of GTS2 at its mouth prevents connectivity of MSB peak with GVF.

**Restoration Potential:** Removing disturbance from the mouth of GTS2 and GVF will restore connectivity.

**Sensitivity:** Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed.

### 9.12 Gawib Tributary #3 coming from the Schieferberg (GTS3)

**Location:** Third of five prominent washes that drain MSB, entering GVF near the middle of ML140.

**Physical:** This is a relatively narrow, dry wash, mostly rocky, and together with GTS1, it comes off the highest peak of MSB.

**Ecological conditions:** a) Connectivity: GTS3 appears to be only seldom used by game in its lower reaches, but game divert from it to GTS1&2; b) Broken rock banks shelter animals that forage in the open channel.

**Vertebrate diversity:** a) High diversity of mammals (21) and reptiles (21); b) Three reptiles of special conservation significance; c) Contains species from adjacent habitats GVF and MSB.

**Threats:** a) Blockage of the mouth area will prevent game movement.

**Restoration Potential:** Opening blocked mouths of washes will restore the main functions.

**Sensitivity:** Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed.

### 9.13 Gawib Tributary #4 coming from the Schieferberg (GTS4)

**Location:** Second from east of five prominent washes that drain MSB into GVF, this is the longest GTS and is also referred to Trans-Schieferberg canyon, as GTS4 starts south of MSB and crosses it.

**Physical:** This is the deepest GTS canyon with relatively steep rocky banks and sandy channel. Its Acacia forest is continuous with the Gawib Acacia forest and its occupants.
Ecological conditions: a) Connectivity: the Trans-Schieferberg canyon (GTS4) is an important game corridor right across the Schieferberg into the Gawib valley; b) Availability of shade and other shelter along the relatively more productive canyon floor; c) Rocky banks shelter animals that forage in the open channel.

Vertebrate diversity: a) High diversity of mammals (21) and reptiles (21); b) Three reptiles of special conservation significance; c) Contain species from adjacent habitats GVF and MSB; d) GTS4 and its adjacent flanks is part of a particularly important corridor for game animals, especially zebra.

Threats: a) Blockage of the mouth areas of GTS3 blocks local and long-distance connectivity; b) Blockage of channel will cause changes in surface hydrology and will change vegetation and substrate dynamics; c) Destruction of perennial vegetation, especially large and complex Acacia trees represents critical habitat loss; d) Proximity and ease of access by people could result in poaching and vandalism.

Restoration Potential: a) Opening blocked mouth of wash will restore the main functions, but may require reintroduction of some species; b) It will take centuries to replace the large Acacia trees; c) Undertake studies of the vulnerable species to determine the significance of population losses and plan possible compensation.

Sensitivity: Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.14 Gawib Tributary #5 coming from the Schieferberg (GTS5)

Location: East-most of five prominent washes that drain MSB into GVF, starting at Bloedkoppie.

Physical: GTS5 is a relatively deep GTS canyon with relatively steep rocky banks and sandy channel. Its Acacia forest is continuous with the Gawib Acacia forest and its occupants.

Ecological conditions: a) Connectivity: the Bloedkoppie canyon (GTS5) intercepts an important game corridor that comes from GTS4 across the Schieferberg into the Gawib valley; b) Availability of shade and other shelter along the relatively more productive canyon floor; c) Rocky banks shelter animals that forage in the open channel.

Vertebrate diversity: a) High diversity of mammals (21) and reptiles (21); b) Three reptiles of special conservation significance; c) Contain species from adjacent habitats GVF and MSB; d) GTS5 and its adjacent flanks is the eastern part of corridor for game animals, especially zebra, but less important than GTS4.

Threats: a) Blockage of the mouth areas of GTS5 blocks local and long-distance connectivity; b) Blockage of channel will cause changes in surface hydrology and will change vegetation and substrate dynamics; c) Destruction of perennial vegetation, especially large and complex Acacia trees represents critical habitat loss; d) Proximity and ease of access by people could result in poaching and vandalism.

Restoration Potential: a) Opening blocked mouth of wash will restore the main functions, but may require reintroduction of some species; b) It will take centuries to replace the large Acacia trees; c) Undertake studies of the vulnerable species to determine the significance of population losses and plan possible compensation.

Sensitivity: Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.15 Plain at Tinkas Rocksculptures (PTR)

Location: Across the eastern 2-km of ML140. The Tinkas Rocksculptures Plain is named after the tourist walking trail through the granite koppies along the southern border of the plain.

Physical: 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.

Ecological conditions: a) High degree of exposure and low productivity; b) Stable substrate well suited for establishing burrows; c) Runoff and species exchange with different adjacent habitats.

Vertebrate diversity: a) 19 mammals and 8 reptiles; b) Low abundance of animals; c) Residents tend to be plains specialists; d) Species from different adjacent habitats also use plains.

Threats: a) Off-road driving destroys many small burrows; b) Mining will permanently destroy the stable surface which takes millennia to form; c) Mining will disturb rich communities in adjacent habitats.

Restoration Potential: Restoration could establish a habitat similar to the Upper Gawib.
**Sensitivity**: Sensitive (2): site should not be permanently damaged and should be used in such a way that ecological function can be restored. A study of tourism and details of biodiversity should be conducted on the adjacent granite Tinkas Rocksculptures, as this may affect the sensitivity rating of PTR.

### 9.16 Plain between Langer Heinrich-Witpoort (PLW)

**Location**: This forms the western section of ML140 and is part of the gravel plain located NW of the Schieferberg and between the Langer Heinrich Mountain and the Witpoortberg.

**Physical**: The hard, smooth surface, known as “desert pavement” is a very stable and structured substratum, established over many aeons (according to Prof. Klaus Heine of the University of Regensburg who has done extensive studies in the Namib, desert pavement development takes several millenia). Shallow, sandy water courses that come off the west flank of the Schieferberg and cross the PLW, 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.

**Ecological conditions**: a) This area has least resources for vertebrates in terms of food, water and shelter, but is home to a suite of desert specialists; b) Following rains, a flush of opportunists may appear temporarily; c) Small local disturbances, such as burrow systems of gerbils or digging by suricats, allow local pockets of vegetation to establish; d) 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; e) Shallow ephemeral pools may occur and support rarely-seen organisms.

**Vertebrate diversity**: a) 15 mammal and 9 reptile species; b) Residents tend to be specialists to the relatively harsh conditions of such a parched, exposed landscape.

**Threats**: a) Off-road driving is here more damaging than in any other habitat; b) Mining will permanently destroy the desert pavement; c) Disruption of mobility of game will reduce the redistribution of nutrients; d) Animals living on the plains are most prone to become road kills; e) Heavy traffic by heavy trucks driving too fast causes extensive dust and noise pollution.

**Restoration Potential**: The originally stable condition of the gravel plains, which took millennia to establish, will be impossible to recreate in this way again for aeons following mining. Restoration can at best achieve recreating another kind of habitat.

**Sensitivity**: Sensitive (2): site should not be permanently damaged and should be used in such a way that ecological function can be restored.

### 9.17 Tumas Watercourse across PLW

**Location**: A shallow water course crossing PLW in a north-westerly direction.

**Physical**: Shallow, sandy water course that comes off the west flank of the Schieferberg and crosses the PLW, 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.

**Ecological conditions**: a) Relatively more resources than the surrounding plains; b) Shrubs provide shelter and food.

**Vertebrate diversity**: a) 15 mammal and 9 reptile species; b) Focus of activity by plains-living vertebrates; c) Continuous habitat with the lower Tumas may allow near-coastal species to penetrate as far as LHU.

**Threats**: a) Blockage will constrain the habitat continuity of the Tumas and reduce population connectivity; b) Animals moving along the wash may cross the road and be killed.

**Restoration Potential**: The drainage line can be re-established with a sandy floor and planting of hummocks, although this will take many decades to fully restore.

**Sensitivity**: Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed.

### 9.18 Schieferberg slope #1 (MSB1)

**Location**: The west-most of the lowest north slopes of MSB which projects into ML140, its eastern boundary extends across GTS1 up to the an eastern boundary zone of the quartzite outcrop at S22.81883 E15.30981.
Physical: This comprises mostly dark schist rocks in ridges or loose flakes/slabs, interspersed with small outcrops of quartzite, and localised patches or veins of quartz. The surface has very shallow and poorly developed soil.

Ecological conditions: a) MSB is the driest of all habitats, as rainwater quickly drains into the many deep cracks, where it is inaccessible; b) The substrate is generally very hard and difficult to burrow in; c) Overall productivity is low and temporary after rare rains; d) Some detritus accumulates in cracks and cavities, so that there is a basic resource base even during dry years; e) The dark colour of the rocks and the north-facing aspect render the surface hot and hostile during daytime; f) Lighter-coloured quartzite outcrops form microclimatic islands where sand lizards shelter and from which they venture onto the surrounding heterogeneous thermal landscape; e) Small vertebrates find shelter in the many cracks in layers of schist, as well as under loose slabs of schist flakes; f) Shallow low caverns into cliffs are used as lairs, dens, roosts and nests.

Vertebrate diversity: a) Moderate number of species of mammals (14) and reptiles (15), and a diversity of birds; b) Low population densities; c) Occurrence of at least four reptile species of special conservation significance especially on and around quartzite outcrops.

Threats: Mining has minimal effects because a) this is a large, continuous habitat with only a small portion in ML140; b) the surface is hard and stable; c) animal populations are low. Threat is low provided that destruction remains confined, and avoids the water courses and quartzite outcrops.

Restoration Potential: Restoration would leave a surface more permeable than it currently is and productivity could perhaps increase above the current condition. Restoration should facilitate the re-establishment 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.

Sensitivity: Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed. The quartz outcrop at S22.81883 E15.30981 and its surroundings in a 100m radius are most sensitive irreplaceable areas.

9.19 Schieferberg slope #2 (MSB2)

Location: The second from west of the lowest north slopes of the Schieferberg which projects into ML140, its western boundary is 200 m east of GTS1 and its eastern boundary is located across the hill that begins at the mouth of GTS2.

Physical: This comprises mostly dark schist rocks in ridges or loose flakes/slabs, interspersed with outcrops of quartzite, and local patches of quartz outcrops. The surface has very shallow and poorly developed soil.

Ecological conditions: a) MSB is the driest of all habitats, as rainwater quickly drains into the many deep cracks, where it is inaccessible; b) The substrate is generally very hard and difficult to burrow in; c) Overall productivity is low and temporary after rare rains; d) Some detritus accumulates in cracks and cavities, so that there is a basic resource base even during dry years; e) The dark colour of the rocks and the north-facing aspect render the surface hot and hostile during daytime; f) Small vertebrates find shelter in the many cracks in layers of schist, as well as under loose slabs of schist flakes; g) Shallow low caverns into cliffs are used as lairs, dens, roosts and nests.

Vertebrate diversity: a) Moderate number of species of mammals (14) and reptiles (15), and a diversity of birds; b) Low population densities; c) A quartzite ridge beyond the south-west corner of MSB2 is the richest point of diversity and abundance of several small mammals and reptiles.

Threats: Mining-related activities has minimal effects because a) this is a large, continuous habitat with only a small portion in ML140; b) the surface is hard and stable; c) animal populations are low. Threat is low provided that destruction remains confined to within the borders, and avoids water courses as well as quartzite outcrops (such as the one located at S22.81883 E15.30981).

Restoration Potential: Restoration would leave a surface more permeable than it currently is and productivity could perhaps increase above the current condition. Restoration should facilitate the re-establishment 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.

Sensitivity: Least sensitive (1): site not important in home range of any species, site degradation would be loss of space for a few species (provided that degradation is confined to within the area’s boundaries).
9.20 Schieferberg slope #3 (MSB3)

Location: The Schieferberg slopes flanking GTS2&3.

Physical: This comprises mostly dark schist rocks in ridges or loose flakes/slabs, interspersed with local patches of quartz outcrops. The surface has very shallow and poorly developed soil.

Ecological conditions: a) MSB is the driest of all habitats, as rainwater quickly drains into the many deep cracks, where it is inaccessible; b) The substrate is generally very hard and difficult to burrow in; c) Overall productivity is low and temporary after rare rains; d) Some detritus accumulates in cracks and cavities, so that there is a basic resource base even during dry years; e) The dark colour of the rocks and the north-facing aspect render the surface hot and hostile during daytime; f) Small vertebrates find shelter in the many cracks in layers of schist, as well as under loose slabs of schist flakes; g) Shallow low caverns into cliffs are used as lairs, dens, roosts and nests.

Vertebrate diversity: a) Moderate number of species of mammals (14) and reptiles (15), and a diversity of birds; b) Low population densities; c) Occurrence of three reptile species of special conservation significance.

Threats: Mining has minimal effects because a) this is a large, continuous habitat with only a small portion in ML140; b) the surface is hard and stable; c) animal populations are low; d) klipspringer and dassie rats that used to occur here, have deserted MSB3.

Restoration Potential: Restoration would leave a surface more permeable than it currently is and productivity could perhaps increase above the current condition. Restoration should facilitate the re-establishment 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.

Sensitivity: Sensitive (2): site should not be permanently damaged and should be used in such a way that ecological function can be restored.

9.21 Schieferberg slope #4 (MSB4)

Location: Schieferberg slope located east of the main plant of LHU.

Physical: This comprises mostly dark schist rocks in ridges or loose flakes/slabs, interspersed with local patches of quartz outcrops. The surface has very shallow and poorly developed soil.

Ecological conditions: a) MSB is the driest of all habitats, as rainwater quickly drains into the many deep cracks, where it is inaccessible; b) The substrate is generally very hard and difficult to burrow in; c) Overall productivity is low and temporary after rare rains; d) Some detritus accumulates in cracks and cavities, so that there is a basic resource base even during dry years; e) The dark colour of the rocks and the north-facing aspect render the surface hot and hostile during daytime; f) Small vertebrates find shelter in the many cracks in layers of schist, as well as under loose slabs of schist flakes; g) Shallow low caverns into cliffs are used as lairs, dens, roosts and nests.

Vertebrate diversity: a) Moderate number of species of mammals (14) and reptiles (15), and a diversity of birds; b) Low population densities; c) Possible occurrence of three reptile species of special conservation significance.

Threats: Mining has minimal effects because a) this is a large, continuous habitat with only a small portion in ML140; b) the surface is hard and stable; c) animal populations are low. Threat is low provided that destruction remains confined, and avoids the water courses.

Restoration Potential: Restoration would leave a surface more permeable than it currently is and productivity could perhaps increase above the current condition.

Sensitivity: Least sensitive (1): site not important in home range of any species, site degradation would be loss of space for a few species (provided that degradation is confined to within the area’s boundaries).

9.22 Schieferberg slope #5 (MSB5)

Location: Schieferberg slopes flanking GTS4 & 5.

Physical: This comprises mostly dark schist rocks in ridges or loose flakes/slabs, interspersed with outcrops of quartzite, and local patches of quartz outcrops. The surface has very shallow and poorly developed soil.

Ecological conditions: a) MSB is the driest of all habitats, as rainwater quickly drains into the many deep cracks, where it is inaccessible; b) The substrate is generally very hard and difficult to burrow in; c) Overall
productivity is low and temporary after rare rains; d) Some detritus accumulates in cracks and cavities, so that there is a basic resource base even during dry years; e) The dark colour of the rocks and the north-facing aspect render the surface hot and hostile during daytime; f) Small vertebrates find shelter in the many cracks in layers of schist, as well as under loose slabs of schist flakes; g) Shallow low caverns into cliffs are used as lairs, dens, roosts and nests; h) Game trails indicate frequent use by game, especially zebra.

Vertebrate diversity: a) Moderate number of species of mammals (14) and reptiles (15), and a diversity of birds; b) Low population densities; c) Part of a frequently used corridor for zebra; d) Occurrence of several reptile species of special conservation significance.

Threats: a) Blockage of game corridor will reduce connectivity; b) There is need to establish how three reptile species of conservation significance will be impacted.

Restoration Potential: Restoration would leave a surface more permeable than it currently is and productivity could perhaps increase above the current condition. Restoration should facilitate the re-establishment of the network of game trails by clearing the area and landscaping such that natural, frequent passage of zebra is again made possible.

Sensitivity: Most sensitive irreplaceable area (4): all mining-related activities have negative effects and should not be undertaken.

9.23 Schieferberg slope #6 (MSB6)

Location: The east-most of the lowest north slopes of MSB which projects into ML140, extending up to Bloedkoppie and GRU.

Physical: 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.

Ecological conditions: a) MSB is the driest of all habitats, as rainwater quickly drains into the many deep cracks, where it is inaccessible; b) The substrate is generally very hard and difficult to burrow in; c) Overall productivity is low and temporary after rare rains; d) Some detritus accumulates in cracks and cavities, so that there is a basic resource base even during dry years; e) The dark colour of the rocks and the north-facing aspect render the surface hot and hostile during daytime; f) Small vertebrates find shelter in the many cracks in layers of schist, as well as under loose slabs of schist flakes; g) Shallow low caverns into cliffs are used as lairs, dens, roosts and nests.

Vertebrate diversity: a) Moderate number of species of mammals (14) and reptiles (15), and a diversity of birds; b) Low population densities; c) Occurrence of several reptile species of special conservation significance.

Threats: Mining has minimal effects because a) this is a large, continuous habitat with only a small portion in ML140; b) the surface is hard and stable; c) animal populations are low. Threat is low provided that destruction remains confined, and avoids water courses and outcrops of quartzite and granite.

Restoration Potential: Restoration would leave a surface more permeable than it currently is and productivity could perhaps increase above the current condition. Restoration should facilitate the re-establishment 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.

Sensitivity: Sensitive (2): site should not be permanently damaged and should be used in such a way that ecological function can be restored.

9.24 Langer Heinrich Mountain (MLH)

Location: The mountain itself falls outside ML140, but some of its foothills and water courses occur either inside, or along the northern border.

Physical: It comprises mostly quartzite. MLH is included because its enormous size (relatively speaking) dominates the surrounding environment and the occurrence of particular kinds of resources in MLH affects adjacent biodiversity.

Ecological conditions: a) Water pools, some of them deep and shaded, occur in steep water courses of MLH, and these cisterns still provide water to animals long after rainfalls; b) A fair amount of perennial vegetation (see report by botanist) represents food to many animals; c) Cracks and caverns in and under rocks and shade in ravines and overhangs make MLH rich in refugia; d) Availability of water, food, safety, and shelter from the elements.
Vertebrate diversity: a) 17 mammals, 12 reptiles, but these numbers are probably underestimated; b) More species can be found in the GTL washes; c) MLH is undisturbed and is an important local bastion for biodiversity.

Threats: MLH falls outside ML140 and may not be directly disturbed, but its ecological functioning will deteriorate if connectivity with the Gawib Valley and Gawib Channel is severed, e.g. if the foothills and water courses (described as separate habitats) are blocked or otherwise disturbed.

Restoration Potential: Restoration of GVF and GCA will restore connectivity with MLH.

Sensitivity: Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.25 Tinkas Mountain (MTK)

Location: 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.

Physical: 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 provide limited shelter for small animals. A few scattered quartzite outcrops occur.

Ecological conditions: 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.

Vertebrate diversity: a) 18 mammals, 12 reptiles; b) Relatively high frequency of transient game animals; c) MTK, together with GTS4, appears to be of key importance as a zebra corridor.

Threats: Blockage of connectivity in MTK, GTL or GVF will disrupt zebra traffic and may cause loss of spatial memory of this area by zebra population.

Restoration Potential: Connectivity needs to be restored. In case rock dumps have been placed here, these should be smoothed and stabilised to the natural configuration of these foothills.

Sensitivity: Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed.

9.26 MLH Foothills of Schist to the West (FSW)

Location: Isolated hills are located NW of the confluence of Reid Wash and Gawib River, opposite the west flank of MLH.

Physical: The river channel is on the one side of the hills, and on the other side is the PLW plain. The terrain has a few prominent ridges.

Ecological conditions: a) Low productivity; b) Ridges provide shelter for residents as well as users of the adjacent habitats.

Vertebrate diversity: 8 mammals, 8 reptiles

Threats: Mining or rock dumps may destroy this area.

Restoration Potential: Restore as schist ridge.

Sensitivity: Least sensitive (1): site degradation would be loss of space for a few species of least concern.

9.27 MLH Foothills of Quartzite Bank (FQB)

Location: These are quartzite slopes that form the bottom terrace of the MLH in the western part of ML140.

Physical: 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 MLH.

Ecological conditions: Except for the lack or paucity of water (as far as could be determined), these foothills are like a microcosm of MLH itself. These hills are difficult to traverse by game, but there are many refugia and shrubs that small vertebrates can use.

Vertebrate diversity: 9 mammals, 13 reptiles, many birds
**Threats**: a) Dust and noise pollution from nearby mining activities; b) Possible inundation with waste rock dumps.

**Restoration Potential**: Restore as quartzite ridge.

**Sensitivity**: Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed.

9.28 **MLH Foothills of Conglomerate Deposits #1 (FCD1)**

**Location**: Western calcrite conglomerate hills that form the lowest mountain terrace towards the centre of ML140, between GTS2&3.

**Physical**: The surface is a stony plain with sparse or very shallow soil, and the underlying calcrite is difficult to penetrate with burrows.

**Ecological conditions**: 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.

**Vertebrate diversity**: Very low: 4 mammals, 2 reptiles.

**Threats**: Use as waste rock dump.

**Restoration Potential**: 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.

**Sensitivity**: Western FCD1 is least sensitive (1): site degradation would be loss of space for a few species of least concern.

9.29 **MLH Foothills of Conglomerate Deposits #2 (FCD2)**

**Location**: Eastern calcrite conglomerate hills that form the lowest mountain terrace towards the centre of ML140, next to GTL4.

**Physical**: The surface is a stony plain with sparse or very shallow soil, and the underlying calcrite is difficult to penetrate with burrows.

**Ecological conditions**: 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.

**Vertebrate diversity**: Very low: 4 mammals, 2 reptiles. Some mammals use the overhangs of FCD2 as shelter.

**Threats**: Use as waste rock dump.

**Restoration Potential**: 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.

**Sensitivity**: Eastern FCD2 is sensitive (2): site should not be permanently damaged and should be used in such a way that ecological function can be restored.

9.30 **Granite Koppies (GKP)**

**Location**: These are located in the eastern quarter of ML140. 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 SE corner of ML140 is where the Bloedkoppie Rocksulpture Hiking Trail is located, where the below-mentioned features can be appreciated by tourists.

**Physical**: The surface of the rocks 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.

**Ecological conditions**: 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 (Withers, 1979), as is generally the case in arid regions (Withers & Edward, 1997; Michael et al., 2008), and this is applicable to ML140. **Vertebrate diversity:** a) 17 mammals, 22 reptiles; b) several ML140 species are only or mainly found on granite koppies or their boundary areas. **Threats:** a) Mining dust and pollution would not only affect the animals living there, but would change the nature of the granite rock surfaces; b) Pollution of the location of ephemeral pools in the interior of the koppies; c) Removal of the boundary to the surrounding plains that is critical for some koppie residents; d) A study should be conducted on the Rocksulpture area and how the significance of this area for animals, as well as for tourism, will affect the adjacent habitats, especially the Plains of Tinkas Rocksulptures. **Restoration Potential:** Granite boulders placed on a foundation of granite bedrock. Some species will need to be reintroduced onto isolated koppies. **Sensitivity:** Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.31 Sandy Patch at Westgate (SPW)

**Location:** 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. **Physical:** 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 sand is well established, semi-stable, and forms a distinct habitat. **Ecological conditions:** a) Rocky ridges surrounded by unconsolidated sand offer patchy microhabitats, increasing heterogeneity; b) Sand is moisture-retaining, which can benefit burrowing animals; c) Surface water will not accumulate after rain. **Vertebrate diversity:** a) High diversity for such a small area: 8 mammals, 8 reptiles; b) Only sighting of the Husab Sand Lizard (presumed to also occur on the Schieferberg); c) This is the only site where three species of Sand Lizards were actually observed; d) Porcupines dig up lily bulbs that grow in the moist sand; e) 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 ML140. Small vertebrates sand-swim and burrow into this small dune, or dig into the sand for food. **Threats:** Mine plant development can easily completely permanently destroy this patch. **Restoration Potential:** 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 wash (GTS2), and to merely remove the fence when the mine closes. **Sensitivity:** Most sensitive irreplaceable area (4): mining-related activities have negative effects and should not be undertaken.

9.32 Ephemeral Pools

**Location:** This habitat is embedded in other habitat types. On ML140, sites with ephemeral pools were found in the granite koppies and on the flanks of Langer Heinrich Mountain and Tinkas Mountain. The current study could not undertake a detailed study of locations of ephemeral pools in the plains within the limited timeframe, but such places are known from nearby areas (e.g. Tinkas plains south of Gawibberg). If found, the location of ephemeral pools should be marked. **Physical:** Temporary pools linger for short periods after rainfall in the riverbed and in shallow bowl-like depressions within granite koppies and also on the open plains with base of flat rock or calcrete. **Ecological conditions:** 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. **Vertebrate diversity:** a) 2 frogs; b) numerous mammals, reptiles and birds come to drink **Threats:** Mining, roads, dust pollution. **Restoration Potential:** Such 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 aestivaling 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.

Sensitivity: Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed, and provided that these do not go directly through an ephemeral pool. The pools themselves are most sensitive (4), irreplaceable sites.

9.33 Quartzite Outcrops

Location: 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. A classic example is the outcrop located at S22.81883 E15.30981.

Physical: 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.

Ecological conditions: a) Lighter-coloured topographically complex surface that represents microclimatic islands on hot and dry surroundings; b) impermeable rock can form bowls where water persists for longer than in the surrounding habitat; c) patches of soil are more developed than in surrounding areas, harbouring some burrowing animals; d) schist hillsides are probably more habitable because of these habitat nodes.

Vertebrate diversity: a) important areas for juvenile sand lizards, including several species of conservation significance; b) these are rare places on schist hill slopes where ephemeral pools can form; c) a lot of the biodiversity described for MSB and MTK 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 MSB.

Threats: a) destruction by mining-related activities will have disproportionate effect on the biodiversity of larger surroundings; b) although it is considered impractical if not impossible to rescue all vertebrates populating an outcrop, an effort should be made to remove them and release them at replacement sites (see below).

Restoration Potential: Re-establish lighter-coloured topographically complex rocky slopes on darker surroundings with smoother surfaces. 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.

Sensitivity: Highly sensitive (3): can possibly tolerate low levels of disturbance, such as quiet roads or other facilities that are not frequently used and can eventually be completely removed, and provided that these do not go directly across a quartzite ridge. The outcrops themselves and a 20-m border are most sensitive (4), irreplaceable areas. The outcrop located at S22.81883 E15.30981 at the boundary of MSB1 & MSB2 is such an irreplaceable site. In case it is unavoidable to completely destroy a quartzite outcrop on schist, research should determine a suitable offset for vertebrate conservation.
10 RECOMMENDATIONS ON MANAGEMENT OF VERTEBRATES AND THEIR HABITATS

This baseline study was conducted to inform the planning of mining operations and the ecological restoration processes after the mining activities. The recommendations presented in this section will therefore incorporate the following themes: advice on how to avoid disturbing certain habitats because doing so would be detrimental to some species of vertebrates; avoidance of disturbing particular habitats because they are ecologically highly sensitive or most sensitive to disturbance; and advice on which areas might need restoration. Extensive research will be required to effectively plan the details of restoration to encompass the ecological processes (or equivalent) described in the introduction (section 5.5 and 5.6). The recommendations in the current section are provided according to species and according to habitats (respectively following sections 8 and 9 of the report).

10.1 Recommendations concerning Species

10.1.1 Mammals

There were several mammals sighted in the ML140, although not all of them are in danger as a result of mining operations. The following recommendations are therefore applying to those mammals that have been deemed in need of care by LHU throughout the mining life cycle.

- Among the permanent residents, there is need to avoid disturbing the Cape hare *Lepus capensis*, which lives in the open areas of the Gawib valley and channel. The Dassie rat *Petromus typicus* have already left mining areas because of disturbance due to noise and other perpetual disturbances that prevent them from basking peacefully in the sun. Care should therefore be taken in order to avoid further alienating the species. In case of the bats, the concern is with their roosting areas, if they are found to be located within the ML140. It is therefore recommended that, before any mountain slopes or koppies are disturbed, it will be important to find any roosts that may occur so as to avoid their destruction. A specialist must be consulted if it should be necessary to shift natural roosting sites of bats, i.e. how to compensate for the loss of a natural roost. Another species that dens localised is hyrax, and the loss of colony may result in loss of connectivity within the metapopulation.

- Among the regular commuters, for whom ML140 represents part of their corridor, Hartmann's mountain zebra, *Equus zebra hartmannae* and gemsbok, *Oryx gazella* are the mammals that require attention. For the zebras, a separate study has been proposed to find out more information because it is believed that the disruption by mining activities and driving on roads at night may have negative consequences for the population of this vulnerable species (Hartmann's mountain zebras tend to be habitual and transfer this information to their young ones and this disruption may break this transgenerational knowledge transfer). The gemsbok on the other hand faces a risk from poachers as an indirect consequence of a well maintained LHU road down to the Swakop River which gives easy access to poachers. It is therefore recommended that the LHU works in collaboration with the Ministry of Environment and Tourism (MET) to keep out poachers from the area near and in the NE corner of the park beyond LHU.

- Most important among the transient commuters is the Chacma baboon, *Papio hamadryas*. The Chacma baboon may be attracted by the open water at the mine (watering pond for dust reduction). A partial fence will not suffice to keep out baboons, and in any case they climb over fences. It is therefore recommended that the LHU reservoirs containing Swakop River water should be replaced with closed tanks to avoid discovery by baboons.

- Many species are important for the process of ecological restoration. Conservation and reintroduction efforts should therefore particularly involve such species. Some species provide ecological functions and services, such as ecological engineering by turning over soil that promotes soil processes, such as water infiltration and nutrient fertilisation, or digging stable burrows, enabling other species that cannot dig to repopulate an area. Most notably, this category of restoration facilitators includes ground squirrels, four-striped grass mouse, Setzer's hairy-footed gerbils, suricats, aardvark, and porcupines. Similarly, zebra sand-bathing sites facilitate local changes in soil characteristics and can facilitate habitat use by other species. Other mammals have the potential to serve as indicators for the status of ecological restoration, or are good pioneers, such as Setzer's hairy-footed gerbils, pygmy rock mouse, suricats. The return of many disturbed species will depend on prior establishment of pioneers. Dung from returning game will also facilitate the return of other...
species (including plants, invertebrates and vertebrates) directly or indirectly dependent on its nutrients. This can be either scattered dung, e.g. of zebra and springbok, or latrines, e.g. of klipspringer and gemsbok. Food webs are complex and affect all species, and it is therefore not plausible to categorically exclude any species from relevance to the restoration process, although it will be important to set restoration targets (e.g., a return to the pre-mining condition may be an impossible or impractical target). When prioritising species to involve in restoration at different stages, key consumers at different trophic levels should be included, preferably from the data available from the baseline study supplemented with further data collected during the course of time (i.e. depending on the restoration target, priority should be on indigenous species previously found on ML140). This is also applicable to reptiles and birds. To recap, it is recommended to continuously improve information and understanding of mammals on ML140 so as to inform ecological restoration.

10.1.2 Reptiles

- It is recommended that snakes, despite none of the ones observed at the ML140 being highly dangerous, need to be captured at the mine plant and released in the wild. This process must be accompanied by the collection and recording of the following data: date, snake identity, GPS location of first sighting and of release site, habitat, notes on exact surroundings, name of first observer, name of person who recorded and photographed it, any other observations. From snakes of conservation significance, e.g., tiger snake and blind snake, DNA samples should be obtained according to the methods described by the herpetologist. All snakes should be treated with care and removed for the snake’s own safety and released away from the mine in habitats that are viable for them. Since many snakes are caught at the mine, information on typical habitats can, for example, be made available on pamphlets so as to increase awareness and provide information on their management. If the habitat is unknown, a location with rocks and shrubs in the vicinity would be a first approximation of what snakes captured in the Gawib valley may require when released. Different places of release should be used over time, so that snakes are not released into overcrowded territories where they may come into conflict with each other.

- The conservation status of the Husab sand lizard, *Pedioplanis husabensis*, is regarded as being potentially threatened (data deficient) and should be upheld. Although at LHU this species is relatively common and widespread, it will important for this species to preserve their key habitats, namely quartzite ridges, especially those that occur on the Schieferberg.

- The same is also recommended for the northern plains sand lizard, *Pedioplanis cf. inornata*, which is a new species to be split from the southern type. This species is uncommon on ML140, and was found on a quartzite ridge and in a vegetated wash of Schieferberg, both being habitats of high conservation levels.

- Two species of snakes, Damara tiger snake, *Telescopus* nov.sp., and Delalande's blind snake, *Rhinotyphlops lalandei*, have special conservation significance, being new or potentially new species. These and other rare species of conservation significance, such as chameleons, monitors, and tortoises should be carefully recorded in detail, removed, and released at sites that will not be disturbed by mining-related activities.

- Several other reptile species are at the edge of their distribution range and conservation principles should be upheld where possible. Notable examples are the rare Namib ghost gecko, *Pachydactylus kochi*, and the spotted desert lizard, *Meroles suborbitalis*. The precautionary principle should be upheld and the destruction of the habitat of the ML140 populations should be avoided until it has been established how these population are connected to the populations lower down in the Tumas basin.

- It is recommended that driving at night in the ML140 and Namib-Naukluft Park in general should be avoided as this leads to road-kills of reptiles. This may significantly affect populations, e.g., of the Giant ground gecko, *Chondrodactylus anguifer namibensis*.

- When planning ecological restoration, the re-establishment of disturbed populations of reptiles should first focus on those species of conservation significance. Furthermore, some species are facilitators on a smaller scale than mammals, e.g. species that dig burrows, such as barking geckos, facilitating living space for other reptiles and invertebrates, or germination sites of plants. Reptiles fill an important position in the foodweb, as they consume other animals, mostly invertebrates, and some are specialists for a certain kind of prey (e.g. blind snakes feeding on termites). On the other hand, many birds feed on reptiles. A healthy, restored ecosystem should therefore contain a range of reptile
species. Depending on the size of the area to be restored, it may suffice to allow reptiles to again recolonise restored areas from adjacent habitats, or, if this is not possible or the area too large, they should be re-introduced.

10.1.3 Birds

- We recommend that driving at night should be avoided on roads or routes outside the mine plant and pits (for this might mesmerize nocturnal birds so they cannot avoid danger); where it is unavoidable, very slow driving is required, and drivers of vehicles should allow birds to move out of the way.
- Driving should be avoided whenever possible on seldom-travelled vehicle tracks or on tracks that could damage broods, especially during the main breeding period – for many Namib birds this is December-March. New tracks should not be established during the main breeding period, and wherever possible only tracks should be used where the path ahead can be seen to be clear of nests.
- Just as has been recommended for baboons above, it is also recommended that the same measures of keeping the water reservoirs covered be exercised to keep birds out of water. Closed tanks are the best way of achieving this. Tailing dams should be managed so as to avoid transportation of pollutants by the birds, i.e. they should not be able to wade in the tailings. It is hereby recommended that the current tailings dam should be fenced on all sides and bird deterrent devices should be activated. Dewatering the tailings will further assist the management of this problem.
- The lappet-faced vulture, *Torgos tracheliotus*, has already lost most of its breeding space in the Gawib valley. It is recommended that for any advice concerning this species, the chairperson of the Namibia Vulture Study group, Mr Peter Bridgeford of Walvis Bay, be contacted.

10.2 Recommendations for Habitats and Ecological Restoration

Data presented in this report show that there are 33 habitat patches within ML140 and are therefore within the area where they can be directly impacted by mining-related activities of LHU. We rated the ecological sensitivity of these habitats to LHU activities on a scale of 1 to 4 with 1 representing the least sensitive and 4 representing the most ecologically sensitive habitat. Generally, we recommend that all sites should not be permanently damaged and should be used in such a way that ecological function can be restored. The recommended environmental management and restoration plans are summarized in Table 2.

Table 2: Habitat management and restoration plan

<table>
<thead>
<tr>
<th>Name of Habitat</th>
<th>Sensitivity level</th>
<th>Management and restoration plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gawib Valley Floor (GVF)</td>
<td>2</td>
<td>• wildlife corridors should be maintained during mine operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• re-establishment of dwarf shrubs and sandy patches where small vertebrates live</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• reintroduction of species for repopulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• connectivity should be re-established at decommissioning</td>
</tr>
<tr>
<td>2. Gawib Channel Acacia-forest (GCA)</td>
<td>3</td>
<td>• removal of trees and groundwater must be avoided</td>
</tr>
<tr>
<td>3. Upper Gawib River (GRU)</td>
<td>2</td>
<td>• avoid and remove blockages of the river</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• removal of hummock-forming dwarf shrubs should be avoided</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• granite koppies should be cleared and will resume hydrological and ecological functioning</td>
</tr>
<tr>
<td>4. Lower Gawib River (GRL)</td>
<td>3</td>
<td>• minor disturbances can be allowed</td>
</tr>
<tr>
<td>5. Gawib Tributaries coming from Langer Heinrich Mountain (GTL)</td>
<td>4</td>
<td>• avoid surface hydrological channel blockage</td>
</tr>
<tr>
<td>6. Gawib Tributaries coming from the Schieferberg (GTS)</td>
<td>4</td>
<td>• avoid entry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• clear blockages of mouths of washes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no disturbances tolerated in first western and two eastern tributaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• open blocked mouths of washes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• manage GTS1 for presence of special species</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• manage GTS4&amp;5 as game corridor</td>
</tr>
</tbody>
</table>
7. Plain at Tinkas Rocksculptures (PTR) 2
- restoration to current state impossible
- avoid off road driving
- re-establishment of dwarf shrubs and sandy patches
- reintroduction of species for repopulation
- connectivity should be re-established at decommissioning
- a study should be commissioned to investigate how the adjacent Rocksculpture area affects PTR

8. Plain between Langer Heinrich-Witpoort (PLW) 2
- avoid off-road and night-time driving
- implement slow driving speed limits
- restoration to current state impossible

9. Schieferberg (MSB) 1, 2, 3, 4
- avoid disturbance of the water courses.

10. Langer Heinrich Mountain (MLH) 4
- avoid any disturbances
- restoration of GVF and GCA will restore connectivity with MLH.

11. Tinkas Mountain (MTK) 3
- avoid blockage to MTK, GTL or GVF
- restore connectivity by removing rock blockages if any

12. MLH Foothills of Schist to the West (FSW) 1
- major disturbances can be tolerated
- restore to schist ridge

13. MLH Foothills of Quartzite Bank (FQB) 3
- avoid disturbance of any kind

14. MLH Foothills of Conglomerate Deposits (FCD) 1, 2
- smooth and stabilise rock tailings to the natural configuration of natural hills to allow passage from and to adjacent habitats.

15. Granite Koppies (GKP) 4
- no disturbances tolerated on koppies and a 50-m border zone around them
- avoid mining dust and other forms of pollution
- avoid pollution of ephemeral pools in the interior of the koppies
- conduct a more detailed study of the Tinkas Rocksculpture area in relation to tourism and vertebrate conservation so as to advise management of this and adjacent areas (PTR and GRU)

16. Sandy Patch at Westgate (SPW) 4
- avoid disturbances in this area
- fence this area on all sides. A standard farm fence (strands) that allow passage of small vertebrates will suffice. Place no entry signs on fence with info on its biodiversity significance
- remove the fence when mine closes

17. Ephemeral Pools 3
- locations of ephemeral pools need to be established; although they do not always carry water, their locations are permanent
- avoid noise, dust and other forms of pollution
- if destruction cannot be avoided, then the top 30 cm of soil 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).

18. Quartzite Outcrops 4
- outcrops on schist and a 20-m border around them should be left completely undisturbed as future source areas for vertebrate populations
11 ACKNOWLEDGEMENTS

This study was conducted with permission of Langer Heinrich Uranium (Pty) Ltd and by the Ministry of Environment and Tourism (MET permit #1367/2009). For support and information I thank Jefta Ampueja, Charles Cleghorn, Angie Kanandjembo, Werner Petrick and Michelle Yates of LHU, Riaan Solomon of MET and his colleagues from Ganab, Marianne Strohbach from the University of Pretoria, and John Irish from Gobabeb. Katharina Dierkes produced the vertebrate habitat map and sensitivity map. Field assistance was provided by Alex Brooks, Taimi Kapalanga, Mycke Matengu and Hiskia Mbura from the Gobabeb Training and Research Centre. Bill Branch gave advice on the identity of some reptiles. Margaret Sikwese and Pardzayi Tagwireyi commented on a previous draft of this report.

12 REFERENCES


### APPENDIX A: MAMMALS AND THEIR HABITATS IN ML-140 OF LHU

#### Status:
- LC: least concern
- LR: low risk
- NT: near threatened
- EN: endangered
- DD: data deficient
- NA: endemic to Namibia
- ND: endemic to Namib Desert

#### Presence:
- s: see animal
- r: report or photo by somebody else
- b, t, d, f: see burrow, tracks, dung, feedingsite
- e: expected

#### Record:
- p: potential
- -: probably absent

#### Habitat:
- M: mountains
- P: plains
- G: Gawib
- S: Swakop
- V: valley
- Ch: channel
- R: river
- T: tributaries
- W: watercourses
- B: benches
- Tinkas: Tinkas
- MLH: granite
- LHM: Schist
- Q: quartzite
- C: conglomerate
- P: patch
- P: plain

#### Appendix A: Mammals and their habitats in ML-140 of LHU biodiversity baseline study phase 2 – vertebrates 27 July 2009

<table>
<thead>
<tr>
<th>Mammals</th>
<th>Status</th>
<th>Record</th>
<th>General habitat</th>
<th>Valley</th>
<th>Channel</th>
<th>Gaweb</th>
<th>River</th>
<th>Tributaries</th>
<th>Tributaries</th>
<th>Tinkas</th>
<th>Plains</th>
<th>Berg</th>
<th>Heinrich</th>
<th>Mountain</th>
<th>Berg</th>
<th>Chaunet</th>
<th>West</th>
<th>Bird</th>
<th>Foothills</th>
<th>Foothills</th>
<th>Congenial</th>
<th>Koppies</th>
<th>Patch</th>
<th>Sand</th>
<th>Water</th>
<th>Westgate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setzer’s hairy-footed gerbil</td>
<td>LC</td>
<td>s</td>
<td>plains near ridges</td>
<td>p</td>
<td>p</td>
<td>p</td>
<td>p</td>
<td>p</td>
<td>p</td>
<td>p</td>
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<td>-</td>
<td>44</td>
</tr>
<tr>
<td>Bushveld elephant shrew</td>
<td>LR</td>
<td>e</td>
<td>woody veg, rocks</td>
<td>p</td>
<td>p</td>
<td>p</td>
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<td>44</td>
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</tbody>
</table>
## APPENDIX B: REPTILES AND THEIR HABITATS IN ML-140 OF LHU

### Status Legend:
- LC = least concern
- NT = near threatened
- EN = endangered
- DD = data deficient
- NA = endemic to Namibia
- ND = endemic to Namib Desert
- r = report or photo by somebody else
- s = see animal
- b, t, d, f = see burrow, tracks, dung, feedingsite
- e = expected presence

### Habitat Legend:
- GVF = General veterinary field
- DCP = Dr. C. Peters
- GCA = Jan G. Caapa
- GTS = General terrestrial specialist
- GRA = Dr. R. K. A. Grieser
- GRL = G. Roderick
- PLC = Dr. P. L. C. E. Le Gallo
- GTS = General terrestrial specialist
- GTS = General terrestrial specialist

### Reptiles

#### TURTLES

- Leopold's tortoise, Stigmochelys pardalis
- Black and yellow tortoise, Geochelone carbonaria

#### SNAKE

- Western black-headed snake, Xyrophis aethiopoides
- Cape cobra, Naja nivea
- Cape dwarf adder, Bitis arietans
- Copperhead, Atheris squamigera
- Rock cobra, Bitis caudalis

#### LACERTID

- Western brown adder, Vipera aspis
- Western adder, Vipera aspis
- Western adder, Vipera aspis

#### AMPHIBIA

- Western short-nosed skink, Trachylepis acutirostris
- Western adder, Vipera aspis
- Western adder, Vipera aspis

### Habitat Map

- Gawib River
- Swakop River
- Gawib Valley
- Swakop River
- Gawib Valley
- Gawib Valley
- Gawib Valley
- Gawib Valley

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**Page 51 of 51**