APPENDIX G: TERRESTRIAL BIODIVERSITY ASSESSMENT

ESIA for the Gamsberg Smelter Project:

Terrestrial Ecology Specialist Assessment

PRODUCED FOR SLR

BY

3Foxes Biodiversity Solutions

Simon.Todd@3foxes.co.za

July 2020

CONTENTS

LIST OF TABLEs

LIST OF FIGURES

ACRONYMS

BMM	Black Mountain Mining (Pty) Ltd.
CBA	Critical Biodiversity Area
CE	Control Efficiency
CITES	Convention on International Trade in Endangered Species
DEFF	Department of Environment, Forestry and Fisheries
DENC	Department of Environment and Nature Conservation in the Northern Cape
DMRE	Department of Mineral Resources and Energy
DTI	Department of Trade and Industry
ECO	Environmental Control Officer
EGI	Electrical Grid Infrastructure
EIA	Environmental Impact Assessment
EMPr	Environmental Management Plan Report
EOO	Extent of Occurrence
ESA	Ecological Support Areas
IUCN	International Union for the Conservation of Nature
mgbl	Metres below ground level
NAAQS	National Ambient Air Quality Standards (South Africa)
NDCR	National Dust Control Regulations
NEMA	National Environmental Management Act, 1998 (Act No 107 of 1998)
NEMBA	National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)
NEMPA	National Environmental Management: Protected Area Act, 2003 (Act No. 57 of 2003)
NFEPA	National Freshwater Ecosystem Priority Areas (NFEPA, 2011)
NPAES	National Protected Area Expansion Strategy
ONAs	Other Natural Areas
PV	Photovoltaic
SABAP	South African Bird Atlas Project
SCC	Species of Conservation Concern
SEA	Strategic Environmental Assessment
SEZ	Spatial Economic Zone
SKEP	Succulent Karoo Ecosystem Programme
TOPS	Threatened or Protected Species

NEMA Regulations (2014) (as amended) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Section 1.4
The expertise of that person to compile a specialist report including a curriculum vitae	Section 1.4
A declaration that the person is independent in a form as may be specified by the competent authority	Page vii
An indication of the scope of, and the purpose for which, the report was prepared	Section 1
An indication of the quality and age of base data used for the specialist report	Section 2
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 3, Section 6
The duration date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 2
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 2
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternative	Section 5
An identification of any areas to be avoided, including buffers	Section 5, Section 6
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers	Section 5
A description of any assumptions made and any uncertainties or gaps in knowledge	Section 2
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 5, Section 6
Any mitigation measures for inclusion in the EMPr	Section 6
Any conditions for inclusion in the environmental authorisation	Section 6
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 7
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and regarding the acceptability of the proposed activity or activities	Section 8
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 7
A description of any consultation process that was undertaken during the course of preparing the specialist report	See Comments and Responses report
A summary and copies of any comments received during any consultation process and where applicable all responses thereto	See Comments and Responses report
Any other information requested by the competent authority	Not applicable

.

DECLARATION OF INDEPENDENCE

I, ..Simon Todd.............................., as the appointed independent Terrestrial Ecological Specialist, in terms of the 2014 EIA Regulations, hereby declare that:

- I act as the independent biodiversity specialist in this application;
- I perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- Regard the information contained in this report as it relates to my specialist biodiversity input/study to be true and correct, and do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA), and the Environmental Impact Assessment Regulations, 2014 under NEMA;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist Terrestrial Ecological report relevant to this application, including knowledge of the NEMA, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the NEMA, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I have no vested interest in the proposed activity proceeding;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I have ensured that information containing all relevant facts in respect of the specialist Terrestrial Ecological input/study was distributed or made available to interested and affected parties and the public and that participation by interested and affected parties was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist Terrestrial Ecological input/study;
- I have ensured that the comments of all interested and affected parties on the specialist Terrestrial Ecological input/study were considered, recorded and submitted to the competent authority in respect of the application;
- All the particulars furnished by me in this specialist Terrestrial Ecological input/study are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the NEMA.

Signature of the specialist: ______________________________

Name of Specialist: Simon Todd

Date: 20 March 2020

1 INTRODUCTION

1.1 Study Overview

Black Mountain Mining (Pty) Ltd. (BMM), part of Vedanta Zinc International, comprises Black Mountain Mine, Swartberg Mine and the Gamsberg Zinc Mine, located near Aggeneys in the Northern Cape. An electrolytic zinc smelter is proposed for treating concentrates produced from the recently commissioned 4 million tonnes per annum (mtpa) zinc mining and concentrator plant at Gamsberg Zinc Mine. The major elements of the proposed Gamsberg Smelter Project would consist of a smelter complex with associated supporting infrastructure as well as a Secured Landfill Facility (SLF) for the disposal of smelter waste called Jarosite / Jarofix, as well as a connecting road of approximately 1 km between the smelter plant and the SLF; a water pipeline of 1.5 km and powerline upgrade. The Gamsberg Smelter Project components and activities relevant to this biodiversity assessment are described in Section 3.

Vedanta has appointed SLR to conduct the required Environmental Authorization (EA) application process for the proposed Gamsberg Smelter Project. SLR has, in turn, appointed Simon Todd of 3Foxes Biodiversity Solutions to provide a specialist Terrestrial Ecology Baseline Study and Impact Assessment of the proposed Gamsberg Smelter Project as part of the required EIA process. A profile of his qualifications is provided in Appendix A. The scope is set out below in Section 1.2.

The purpose of the Terrestrial Ecology Specialist Study is to describe the ecological features and sensitivity of the proposed Gamsberg Smelter Project area of influence; identify and assess the potential impacts of the proposed Gamsberg Smelter Project, and propose suitable mitigation and monitoring measures.

A site visit and desktop review of the available ecological information for the area was conducted to characterise the biodiversity features of the proposed Gamsberg Smelter Project area. This information was used to derive an ecological sensitivity map to inform the assessment of alternatives and impacts of the proposed Gamsberg Smelter Project. Impacts are assessed for the different phases of the proposed Gamsberg Smelter Project. Various mitigation measures are recommended to mitigate the potential impact of the proposed Gamsberg Smelter Project, which will be included in the Environmental Management Programme (EMPr). The scope of study is set out below.

1.2 Scope of Work

The Scope of Work for the Terrestrial Ecology Study for the proposed Gamsberg Smelter Project includes the following:

- Screening and ranking of alternative site locations for the proposed smelter and SLF based on existing biodiversity sensitivity mapping for the potential area of influence from existing data in order to assess biodiversity risks and inform the selection of site locations associated with the proposed Gamsberg Smelter Project components;

- Desktop review, including information related to potential impacts of air quality emissions and particulate (including dust and a range of potential pollutants) fallout on vegetation to support air quality thresholds or critical loads or values[1] used to generate outputs from the air dispersion model and assessment of impacts;
- Compilation of scoping report inputs to identify potential biodiversity issues to be addressed in the specialist assessment;
- Undertake a 3-day site visit (excluding travel) to assess the status of the terrestrial biodiversity in the proposed Gamsberg Smelter Project area of influence with specific attention on the proposed Gamsberg Smelter Complex and SLF footprints. Where feasible, the site visit aimed to identify potential effects from the existing Gamsberg Zinc Mine on habitats in or near the proposed Gamsberg Smelter Project components;
- Compile a detailed baseline ecology report based on information from fieldwork for the proposed Gamsberg Smelter Project, supported by information from previous surveys at Gamsberg Zinc Mine, highlighting any observed impacts from the existing Gamsberg Zinc Mine's mining activities;
- Assess construction, operational and decommissioning pre- and post-mitigation impacts on flora and fauna (direct and indirect), including from air emissions and potential ground or surface water contamination, drawing on the results of modelling studies. Impacts will be assessed using SLR's impact assessment methodology (Appendix B);
- Interpret the description of residual impacts (i.e. impacts remaining after all feasible mitigation has been applied) in the context of the mitigation hierarchy and the existing Gamsberg Biodiversity Offset Agreement (between BMM and Northern Cape Department of Nature Conservation (DENC), signed on 16 October 2014), and identify if any additional Biodiversity Offsets may be required;
- Describe potential cumulative impacts;
- Work with SLR's biodiversity coordinator and air quality consultant (Airshed Planning Professionals) to understand the air dispersion modelling process, its results, and interpret findings taking into account the basis for the existing Gamsberg Biodiversity Offset requirements;
- Recommend feasible and practical mitigation measures for inclusion in the EMPr, including potential Biodiversity Offset measures or additional conservation actions that could be undertaken to compensate for biodiversity impacts, if required, including translocation and replanting options; and
- Recommend monitoring requirements building on the existing flora and fauna monitoring protocols (Desmet *et al*. 2018 and Endemic Vision 2018, respectively) developed for the Gamsberg Zinc Mine with a specific focus on monitoring biodiversity changes in the proposed Gamsberg Smelter Project area of influence and to inform adaptive management.

[1] Critical Loads are defined as: " a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge". Critical levels are defined as "concentrations of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may occur according to present knowledge". It is important to distinguish between a critical load and a critical level. The critical load relates to the quantity of pollutant deposited from air to the ground, whereas the critical level is the gaseous concentration of a pollutant in the air. Particulates are solid materials transported in gaseous emissions and are thus not gaseous concentrations but a solid concentration in a gaseous vector.

2 APPROACH AND METHODOLOGY

2.1 Overall Approach to the Study

This Terrestrial Ecological Baseline and Impact assessment is conducted according to the EIA Regulations, 2014 (Government Notice Regulation 326) as well as Notice 320 (2020); procedures for the assessment and minimum criteria for reporting on identified environmental themes published in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) (as amended. This includes adherence to the following broad principles:

- That a precautionary and risk-averse approach be adopted towards projects which may result in substantial detrimental impacts on biodiversity and ecosystems, especially the irreversible loss of habitat and ecological functioning in threatened ecosystems or designated sensitive areas: i.e. Critical Biodiversity Areas (as identified by systematic conservation plans, Biodiversity Sector Plans or Bioregional Plans) and Freshwater Ecosystem Priority Areas;
- Demonstrate how the proponent intends complying with the principles contained in Section 2 of the NEMA, which, amongst other things, indicates that environmental management should:
  - In order of priority aim to avoid, or minimise and remedy, disturbance of ecosystems and loss of biodiversity (i.e. implementation of the Mitigation Hierarchy);
  - Avoid degradation of the environment;
  - Avoid jeopardising ecosystem integrity;
  - Pursue the best practicable environmental option by means of integrated environmental management;
  - Protect the environment as the people's common heritage;
  - Control and minimise environmental damage; and
  - Pay specific attention to management and planning procedures pertaining to sensitive, vulnerable, highly dynamic or stressed ecosystems.

These principles serve as guidelines for all decision-making concerning matters that may affect the environment. As such, it is incumbent upon the proponent to show how proposed activities would comply with these principles and thereby contribute towards the achievement of sustainable development as defined by the NEMA. In order to adhere to the above principles and best-practice guidelines, the approach to the study is summarised below.

The study included data searches, desktop studies, site walkovers / field survey of the potentially affected area and baseline data collection, with the aim of describing biodiversity pattern and ecological process features. These include:

- The broad ecological characteristics of the site and its surrounds in terms of any mapped biodiversity priority areas (e.g. CBAs), spatial components of ecological processes and/or patchiness, patch size, relative isolation of patches, connectivity, corridors, disturbance regimes, ecotones, buffering, viability, etc., in the context of the wider landscape.

- The vegetation communities including the main vegetation types, their extent and interaction with neighbouring types, soils or topography, and presence of threatened or vulnerable ecosystems (*cf. SA vegetation map/National Spatial Biodiversity Assessment, fine-scale systematic conservation plans, etc.*);
- The presence of any unusual landscape features or important vegetation associations such as seasonal wetlands, alluvium, quartz and calcrete patches in the vicinity of the proposed Gamsberg Smelter Project development footprint area;
- The flora species including presence of IUCN Red List species (giving GPS coordinates of their location) and the likelihood of other Red List species, Species of Conservation Concern (SCC), and Protected Species under the Northern Cape Nature Conservation Act (No. 9 of 2009) occurring in the vicinity (include degree of confidence). Protected Trees under the National Forest Act, 1998 (Act No. 84 of 1998);
- The presence and extent of alien and/or invasive plant cover, and whether any infestation is the result of prior soil disturbance, and any requirements for management, and any other land use threats;
- The confirmed and likely presence of terrestrial fauna that are impacted by existing land uses at the site or which may be affected by the proposed Gamsberg Smelter Project with specific attention to SCC that are endemic to the region, threatened or commercially traded (e.g. TOPS, CITES-listed); listed as protected species the Northern Cape Nature Conservation Act (No. 9 of 2009, or of cultural significance.
- Ecological process features such as the 'drivers' of ecosystem functioning on the site, such as fire, hydrological processes or corridors, and any possible changes in these processes that may be induced by the proposed Gamsberg Smelter Project. These include mapped spatial components of ecological processes such as corridors along water courses or upland-lowland gradients, potential migration routes, and *vegetation boundaries* such as edaphic interfaces, upland-lowland interfaces or biome boundaries. Changes could include alteration in fire frequency or surface water drainage.

In addition, the terrestrial ecology study will:

- Identify any further studies that may be required during or after the EIA process such as species specific monitoring or monitoring and reporting on survival rates of translocated plant species;
- Identify legislation, permits and standards relevant to biodiversity applicable to the proposed Gamsberg Smelter Project activities; and
- Describe and present graphically on imagery the opportunities and constraints of the proposed Gamsberg Smelter Project development.

2.2 Data Review

The primary sources of biodiversity information for the proposed Gamsberg Smelter Project Area are the specialist studies completed for the Gamsberg Zinc Mine EIA in 2013. Relevant biodiversity studies include:

- The Vegetation Baseline and Impact Assessment report by Desmet (2013);
- The Terrestrial Fauna and Aquatic Biodiversity report by GroundTruth (2013); and
- The Fauna and Flora report by Simon Todd Consulting (2013).

Subsequent studies after the Gamsberg Zinc Mine ESIA that were reviewed include:

- An Updated Fauna and Flora report by 3Foxes Biodiversity Solutions (2017), which addressed the status of biodiversity within the immediate vicinity of the Gamsberg Zinc Mine pit as well as the concentrator plant, as observed during the construction period of these features.

Additional source literature and data used to inform the baseline terrestrial ecological description are summarised below.

Ecosystems and Vegetation

- National vegetation types and their conservation status were extracted from the South African National Vegetation Map (Mucina & Rutherford 2006 and 2018 update) as well as the National Biodiversity Assessment (NBA) (2018), where relevant;
- Fine-scale vegetation mapping of the Northern Cape prepared by Desmet *et al.* 2005 which was used as the basis for deriving sensitivity mapping for the Gamsberg Zinc Mine EIA;
- Critical Biodiversity Areas (CBAs) were extracted from the Northern Cape Critical Biodiversity Areas Map (Holness & Oosthuysen 2016);
- Freshwater and wetland information was extracted from the National Freshwater Ecosystem Priority Areas assessment (NFEPA) (Nel *et al.* 2011).
- The threat status of plant species was derived from the Threatened Species Programme, Red List of South African Plants Online (2020), available at http://redlist.sanbi.org/index.php.

Fauna

- Lists of mammals, reptiles and amphibians which are likely to occur at the site were derived based on distribution records from the literature and Animal Demography Unit (ADU) Virtual Museum spatial database (http://vmus.adu.org.za/);
- Literature consulted includes Branch (1988) and Alexander and Marais (2007) for reptiles, Du Preez and Carruthers (2009) for amphibians, and Friedmann and Daly (2004) and Skinner and Chimimba (2005) for mammals;
- The faunal species lists provided are based on species which are known to occur in the broad geographical area, as well as a preliminary assessment of the availability and quality of suitable habitat at the site; and
- The conservation status of mammals is based on the IUCN Red List Categories (EWT/SANBI 2016), while reptiles are based on the South African Reptile Conservation Assessment (Bates *et al.* 2014) and amphibians on Minter *et al.* (2004).

Additional studies & Literature Review

Modelling studies and assessments undertaken for the proposed Gamsberg Smelter Project were reviewed, including the air quality impact assessment (Airshed 2020); the hydrogeological study (SLR 2020) and the surface water assessment (SLR 2020b) and used to extrapolate and interpret modelled results to identify and assess ecological impacts. Modelled air quality results at different agreed thresholds or critical values for vegetation based on literature review were provided by Airshed (2020) as shape files. Literature consulted to determine appropriate vegetation thresholds and tolerances for air emissions and particulate fall out to inform the assessment of air quality impacts is summarised in Appendix 7.

2.3 Mapping of Ecological Constraints and Sensitivity

The mitigation hierarchy was implemented in the selection of alternative sites by including the avoidance of areas that were previously mapped as sensitive biodiversity areas. Ecological constraints mapping previously prepared for the Gamsberg Zinc Mine by Desmet (2013) and based on definition of areas as 'irreplaceable', 'constrained' or 'flexible' was used to inform the assessment of alternative sites for the smelter and SLF during the Scoping Phase to assist with confirming the preferred site for further assessment. Biodiversity criteria were included amongst other technical, cost and traffic related criteria.

Following fieldwork in January 2020, ecological sensitivity mapping was prepared as a basis for providing an updated biodiversity assessment of alternatives and is presented in Section 5. This was done by integrating the fine-scale vegetation mapping (compiled by Desmet 2013) with updated delineation of specific habitat units where differences were observed in the field. Units were assigned sensitivity values based on their ecological properties, conservation value and the potential or confirmed presence of species of conservation concern (listed and endemic species).

Boundaries of Critical Biodiversity Areas (CBAs) and Ecologically Sensitive Areas (ESAs) were not included in the sensitivity mapping as the mapping represents actual ecological features as observed on the ground, whereas the CBA mapping includes spatial features such as representivity that cannot be observed in the field. As such, the sensitivity mapping represents an independent baseline sensitivity assessment that can be compared against the CBA mapping and the actual sensitivity of the site-specific features and biodiversity values.

2.4 Fieldwork

A field assessment of the proposed Gamsberg Smelter Project footprint and alternative sites was conducted from 27-29 January 2020. The fieldwork had been delayed since late 2019 to wait for the start of the typical rainfall season to improve conditions for detecting flowering plants. Unfortunately, although there had been some rain in early January prior to the site visit, this was not sufficient to trigger a full-scale growth event in the vegetation of the site. The area has been experiencing lower than average rainfall for at least the last four years, averaging less than 50 mm per year.

Despite the low rainfall, field survey conditions were considered 'reasonable'. Areas that had received some runoff and areas towards the south of the study area were fairly green with many shrubs and grasses in flower and with occasional forbs and annuals present. Those areas with shallow soils were however dry with very little active growth by the vegetation, with the result that it was difficult to generate comprehensive plant species lists for these areas.

In order to reduce the potential limitations associated with the partly dry conditions, specific attention was given to conducting walking transects and searches in habitats important for conservation such as calcrete and quartz patches within the proposed Gamsberg Smelter Project footprint and surrounding areas. This habitat-based approach is considered more conservative than a species-based approach as it allows for sensitive areas to be identified and delimited based on the presence of certain habitats regardless of whether the associated specialist species are observed or not. Distribution and mapping of vegetation types was confirmed and specific locations of threatened or endemic plant species were recorded where these were observed. It is however important to note that the proposed footprint alternatives were not exhaustively searched for species of concern, but that the observations were used to provide an indication of the identity and density of such species for comparative purposes.

Evidence of faunal presence was recorded through direct sightings or evidence of tracks, scats, or burrows and active searching amongst rocks, when conducting plant transects. Faunal presence at the site is however derived largely from previous visits to the site under more favourable conditions as well as the results of camera trapping on the plains between Gamsberg and the N14, conducted in 2017. Detailed systematic bird surveys were not conducted during the January 2020 survey due to the generally dry conditions that are not reflective of the birds likely to occur. Thus information on the avifaunal assemblage of the proposed Gamsberg Smelter Project area is inferred based on a subset of the bird surveys conducted during the 2017 biodiversity assessment conducted by 3Foxes Biodiversity Solutions. This consisted of 12 x 500m transects on the plains between Gamsberg and the N14 road. This is considered to represent a sufficiently recent and comprehensive survey that provides a significantly better picture of the avifauna of the area compared to the available SABAP data.

2.5 Limitations and Assumptions

Survey timing for vegetation: although the field survey was undertaken during an usually favourable time of year for detecting flowering plants, the limited rainfall over the past four years has restricted the ability to detect the small flowering succulents, many of which are tiny, measuring only a few millimetres in size. This necessitated a habitat-based approach from which the likely presence of SCC could be inferred based on previous plant records and the species that were confirmed.

Faunal presence: Owing to the low abundance of fauna in the study area due to the arid conditions and mine disturbance associated with the existing Gamsberg Zinc Mine, and limited time to conduct thorough surveys of fauna, presence of fauna was supported by information obtained from previous camera trapping (3Foxes Survey in 2018) and survey data over a broader area around the proposed

Gamsberg Smelter and Gamsberg Zinc Mine area of influence thereby ensuring a conservative approach was taken.

Impact of dust on succulent plants: although dust fall out is monitored around the Gamsberg Zinc Mine, no effective monitoring of dust impacts on vegetation has been conducted that can provide a basis for confirming the actual impacts of the existing mining activities to date or which validates the basis for the existing mine offset. This restricts understanding of the degree to which the 'baseline' for the proposed Gamsberg Smelter Project assessment may have altered since mining began. As a result, this ecological assessment has had to assume that the original basis for predicting dust impacts on vegetation and offset requirements used in the Gamsberg mine ESIA remains valid (i.e. 20 $mg/m^2/day$ and 50 $mg/m^2/day$) (See Section 3.3). Note: implementation of dust monitoring and its ecological impact on vegetation based on the Flora Monitoring Protocol commenced in August 2020, a study contracted to an independent specialist (EkoInfo).

Air quality influence on vegetation: Little research has been conducted globally on the influence of different air emissions on vegetation and there is almost no information on the effects of dust, other particulates (including a range of heavy metals) and gaseous emissions on succulents. Different types of air emissions have variable effects depending on the climate, soil, plant physiology and local conditions, and it is very difficult to extrapolate results of air emissions on one vegetation type in a different climatic zone to potential effects on succulents in an arid environment. Nonetheless, a literature survey was undertaken to check the degree to which the thresholds that have been used to generate air emission modelling are within conservative thresholds for different plant types to predict the extent of potential impacts (see Section 3.4.).

3 CONTEXT OF THE SMELTER PROJECT AND RELEVANT STUDIES

The existing Gamsberg Zinc Mine and Biodiversity Offset, and the various components of the proposed Gamsberg Smelter Project are described below to provide context for this ecological assessment. It also presents an overview of the air quality and groundwater quality modelling for the proposed Gamsberg Smelter Project that has been used to inform the assessment of ecological impacts in this study.

3.1 The Existing Gamsberg Mine Project

The Gamsberg Zinc Mine is an approved open pit zinc mine and is currently approved to mine 10 million tons per annum (mtpa) to produce zinc concentrate. The final open pit is expected to cover a total area of 600 ha (with a size of 2 220 x 2 700 m and a depth of 650 m) and to involve the extraction of some 1.65 billion tons of material. Large trucks of 220 to 300 ton capacity haul ore from the pit to the primary crusher next to the open pit on the northern slope where it is crushed and then transported to the ore stockpile via a conveyor. Waste material is tipped over the edge to form a waste rock dump (Figure 1) which will cover an estimated 490 hectares. An estimated 1.5 billion tons of waste rock will be generated during the life of mine.

Ore is processed at the concentrator plant which will produce 1.1 mtpa of zinc concentrate and comprises a milling circuit; ore stockpile; flotation; dewatering, filtration and zinc concentrate handling; material lay down and storage areas; diesel and petrol bulk storage; equipment wash areas; and additional on-site plant infrastructure. Currently 4 mtpa is being mined and processed through one of two approved processing plants (the second processing plant has not been constructed yet).

A slurry of tailings material is produced by the concentrator plant, sent to a thickener to reduce the water content, and then pumped to the tailings storage facility to the north of the mine area. Here percolated water from the tailings dam is extracted to a return water dam which are then returned to the process plant and re-used in the concentrating process. At full mine capacity, approximately 9 mtpa of tailings will require one tailings dam of 290 ha to store 132 million tons of tailings. Phase 1 of the tailings facility has been constructed to date and is lined with a 1.5 mm thick HDPE geomembrane liner over a geotextile layer. This will be enlarged to cover the full extent of the approved Tailings Storage Facility footprint.

Water from the Orange River is piped in two circuits to Black Mountain Mine (also supplying the towns of Pella, Aggeneys and Pofadder) and Gamsberg Zinc Mine by Sedibeng Water. Both the circuits consist of a flash mixer, clarifier, dosing system, sludge handling facility, balancing reservoir, high lift pump house, high lift pipelines and Horseshoe Reservoir with associated facilities. The current water demand, with the Black Mountain Mine operation and Phase 1 concentrator plant at Gamsberg Zinc Mine, is 28 ML/day, but the existing intake water pumping system has been designed for 40.8 ML/day.

From the Horseshoe Reservoirs the bulk pipeline to the Gamsberg Zinc Mine take-off runs below ground for 4 km and above ground for 3 km from the Main Bulk Water Pipeline to the Gamsberg Zinc Mine reservoir.

Figure 1. Current open pit (East pit) (top left); waste rock dump (top right); and tailings storage facility (bottom)

The Gamsberg Zinc Mine was approved in 2013 subject to a requirement in the EA to implement a Biodiversity Offset Agreement as described in Section 3.3.

3.2 The Proposed Smelter Project

3.2.1 Summary Description

The proposed Gamsberg Smelter Project involves a new zinc smelter and associated infrastructure to beneficiate 680 000 tpa of zinc concentrate produced by the mine's concentrator plant to produce 300,000 tpa of zinc ingots and 450,000 tpa of sulphuric acid for export. Besides the zinc ingots and sulphuric acid, the main by-products from the smelter process comprises Jarosite iron residue (290,000 tpa) which will be fixed with lime and cement and disposed of as Jarofix at the SLF; while manganese dioxide cake (20,000 tpa), Cobalt-Nickel cake; and Copper-Cadmium cake will be stockpiled in dry form for sale.

The proposed Gamsberg Smelter Project comprises the following infrastructure components:

- A smelter complex using the Roast-Leach-Electrowinning (R-L-E) process with Jarosite precipitation and Jarofix conversion process;
- The development of a Secured Landfill Facility (SLF) for the disposal of the Jarofix;

- A new 7-km water pipeline from Horseshoe reservoir to the proposed Gamsberg Smelter Complex;
- A laydown area and business partner camp for the construction phase;
- A paved road of approximately 1 km between the proposed Gamsberg Smelter Complex and SLF; and
- Transmission line upgrades.

The concentrate from the concentrator plant that will be smelted in the proposed Gamsberg Smelter has a design composition of 50% zinc; 30% sulphur; 10% iron; 3.5% manganese and 4.5% lead, copper and silicon dioxide; 0.5% lead, 0.3% copper and 0.2% carbon. The smelter process to generate the products is detailed in the Project Description of the ESIA.

The proposed layout and alternatives for the proposed Gamsberg Smelter Project are illustrated in Figure 2 and Figure 3. The footprint of the different components of the development occupies approximately 22 ha for the smelter, 21 ha for the SLF facility, 15 ha for the laydown area and 12 ha for the business partners' camp which together with the road and pipeline totals approximately 90 ha.

Table 1. Summary of Smelter Project components and activities and potential ecological implications

Component	Infrastructure and Activities	Aspects with Potential Ecological Implication
Smelter Complex, SLF, Business Partner Camp	Construction: Site clearance of 22 ha Smelter; 21 ha SLF; 15 ha laydown; 22 ha business partner camp. Total approximately 90 ha (all works areas). Site preparation: excavation, levelling with heavy machinery. Staff: 1500 construction workers.	• Site clearance/ vegetation removal; • Dust and air emissions; • Noise generation; • Traffic movements • Stormwater runoff / erosion • Hydrocarbon spills/leaks • Construction worker presence/ trampling / litter etc.
Smelter Complex	Operation: Raw material storage & handling from mine processing plant; roasting and leaching, acid storage and loading, manganese removal; zinc enrichment, melting and casting of zinc ingots; effluent treatment; water treatment; ozone plant for manganese removal; calcine silo, gypsum removal, laboratory and workshops and other support infrastructure and requirements. Smelter stacks will be 80 m height. Other non-smelter infrastructure will include a business partners camp; sewage treatment plant; change house; canteen; and fire and first aid station and stormwater dam. Smelter would operate 24 hours a day for the 15-year expected life of mine.	• Dust generation from loading/ unloading, vehicle dust entrainment • Air emissions (lead, zinc, SO_2, NO_2, dioxins/furans) from smelter stacks and fugitive emissions from the smelter complex; • Noise generation; • Vehicle movement; and • Staff presence & activities. **Note:** contaminants such as manganese, cobalt, cadmium, arsenic and mercury are not expected to exit the stacks as air emissions. These will be components of by-products for sale or Jarosite waste.
Road from Smelter to SLF	Operation: Transport of approximately 23 trucks per day (carrying 30 tons per load) of Jarofix and ETP cake to SLF.	• Altered runoff (drainage lines); • Windblown dust from trucks & cleared areas; • Uncontrolled off-road vehicle use on sensitive vegetation; and • Risk of fauna collision / mortality.

Component	Infrastructure and Activities	Aspects with Potential Ecological Implication
SLF	Construction: Clearance and site preparation; Construction and laydown of Type 1 liner system and stormwater drainage channels to 5000 ha stormwater dam. Operation: Deposition of Jarofix and ETP cake on the SLF. Reuse of collected water.	• Site clearance/ vegetation removal; • Dust from SLF area; and • Potential leachate (with Lead, Antimony and Sulphate) to groundwater and effect on groundwater dependent vegetation Note: Air emissions from the SLF Jarosite not expected as hardens to cement-like substance.
Pipeline	Construction: Installation of above ground pipeline of 7 km from Horseshoe Reservoir to a 10 ML reservoir at the Smelter Complex within the servitude of an existing pipeline.	• Minimal vegetation clearance / loss / damage for access and installation in already disturbed area
Powerline	Upgrade of an existing 20-km 132 kV powerline from the Aggeneys substation (west of the Gamsberg Mine).	• No effective change from current situation

The detailed smelter process is described in the Project Description of the ESIA Report (SLR, 2020).

3.2.2 Alternatives

Three location options were proposed for the Gamsberg Smelter complex and three for the SLF (shown in Figure 3) and were selected to avoid irreplaceable and constrained habitats that were previously mapped for the Gamsberg Mine EIA by Desmet (2013). Two of the proposed Gamsberg Smelter complex locations are south of the N14 (Alternative 2 and 3) and the third is located north of the N14. Only SLF Alternative 3 is located south of the N14 and the other two alternatives are located north of the N14. Alternatives located south of the N14 are in areas mapped as CBA Category 1 and those north of the N14 road are in CBA Category 2.

The assessment of site alternatives for the smelter and SLF were informed by various criteria including biodiversity, technical, economic and traffic safety considerations. The identification of these alternatives during the scoping phase took account of the known site constraints and were sited to avoid known sensitive habitats (irreplaceable or constrained areas) based on previous surveys in the area (Desmet 2013). The alternatives were verified for their ecological sensitivity during the field work for this ecological assessment in January 2020. The additional information collected on-site has since shown that some of the alternatives are within areas considered to be ecologically sensitive. An analysis of the ecological constraints associated with the alternatives is described in Section 5, following the baseline site description in Section 4 which provides the context for each alternative.

Although biodiversity sensitivity was taken into consideration in the alternatives analysis by selecting alternatives outside of irreplaceable habitat, Smelter complex Alternative 3 and SLF Alternative 3 were selected by the Black Mountain Mining (Pty) Ltd as the preferred locations during the Scoping Phase, primarily for technical, cost and traffic (safety) considerations. Additional mitigation to minimise and monitor biodiversity impacts of the SLF 3 location in particular will be required and is included in this report. The ecological sensitivity and ranking of the alternatives are described in Section 5.

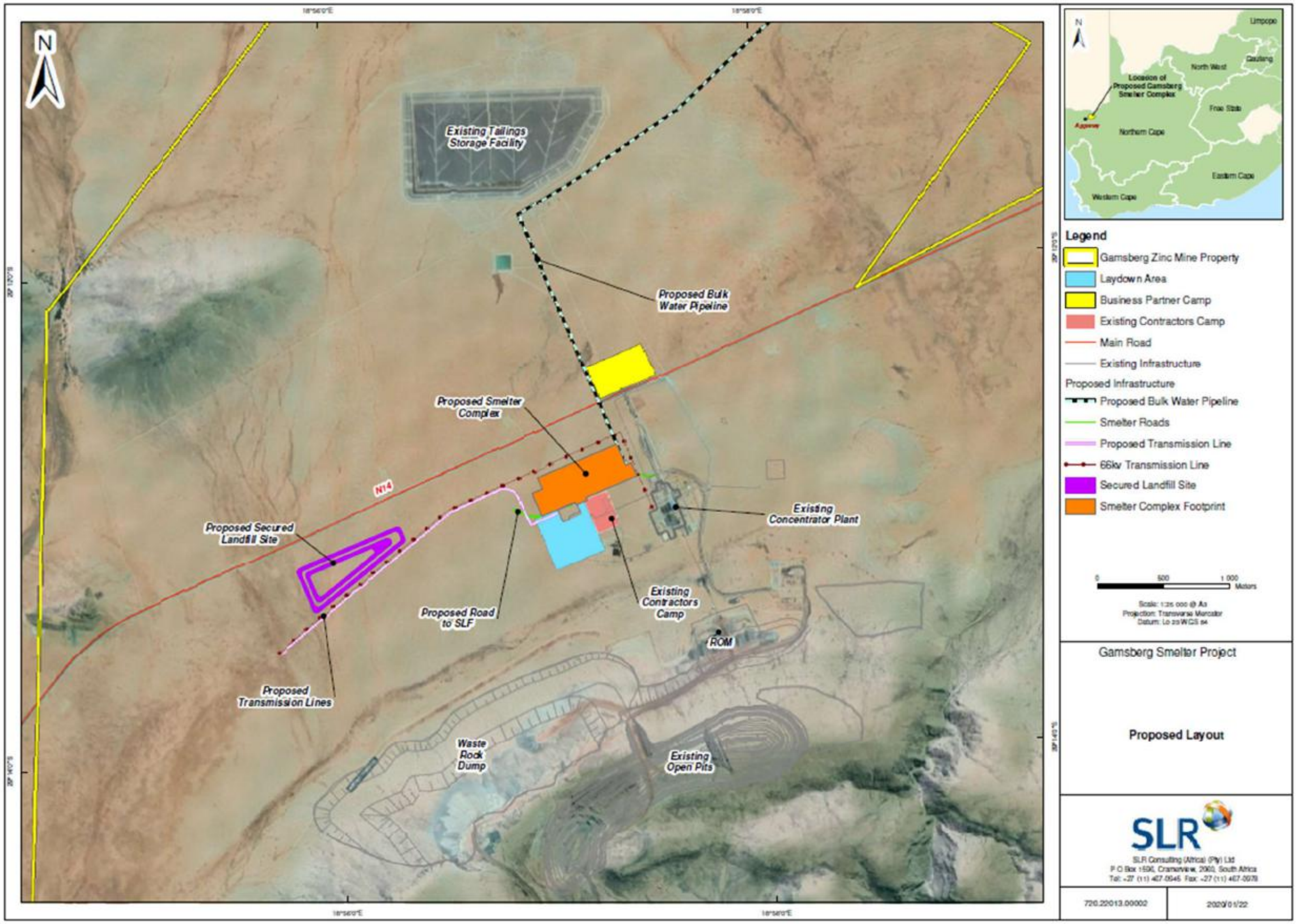


Figure 2. Layout of the proposed Gamsberg Smelter Project showing components assessed in this Terrestrial Ecological Specialist study

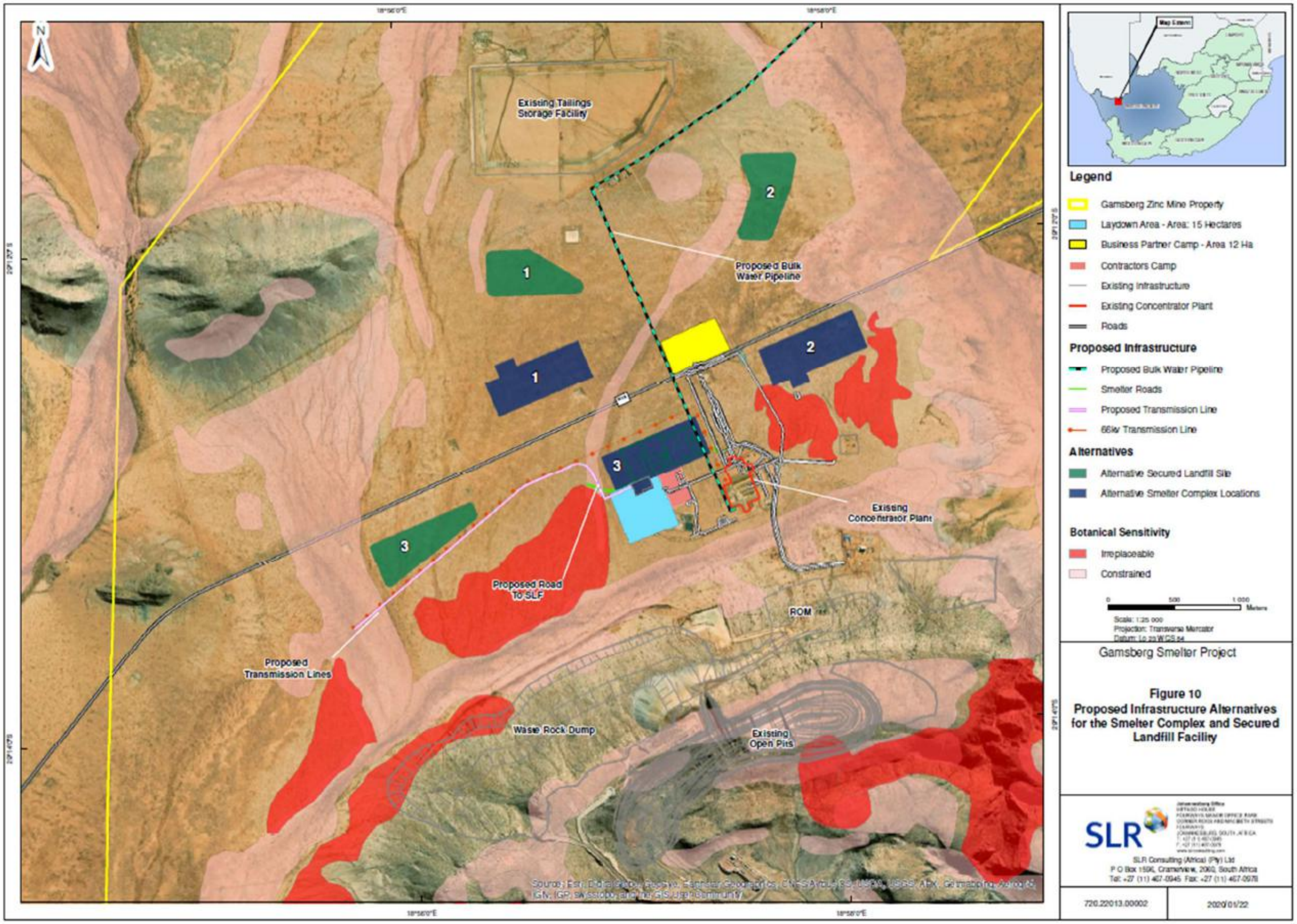


Figure 3. Layout of the proposed Gamsberg Smelter Project, showing the three alternatives for the smelter complex and SLF sites. The sensitivity mapping is based on mapping compiled by Desmet (2013) for the Gamsberg Zinc Mine ESIA.

3.3 Biodiversity Offsets for the Gamsberg Zinc Mine

The proposed Gamsberg Smelter Project must be seen in the context of the original ESIA for the Gamsberg Zinc Mine, its conditions of authorisation and the biodiversity offset requirements that were associated with the mine development (Botha *et al*. 2013). Determination of the Gamsberg Zinc Mine offset (Botha *et al*. 2013) was based on quantification of the footprint of each of the mapped habitat units from the fine-scale vegetation mapping within i) the mine and associated infrastructure footprint, ii) all habitat units within the modelled 50 mg/m^2/day dust deposition zone (i.e. residual impacts due to dust fall-out) and iii) irreplaceable habitats within the 20 mg/m^2/day dust deposition zone (including all calcrete gravel plains habitat) (i.e. residual impacts due to dust fall-out), and iv) the modelled groundwater drawdown zone. That is, the offset calculation essentially assumed the 'loss' of biodiversity in these areas either through complete removal or smothering for the Gamsberg Zinc Mine infrastructure or from dust impacts or from drop in the water table for groundwater dependent biodiversity (notably associated with the Gamsberg Kloof). Although the offset was calculated assuming the loss of biodiversity within these areas, some components, namely calcrete gravel patches, are considered to be 'irreplaceable' habitat for the presence of locally endemic succulents, and would thus generally be regarded as 'no go' areas. The affected habitats and required offsets as calculated by Botha *et al.* (2013) are described below in Table 2, with offset area shown in Figure 4 with offsets secured to date shown in Figure 5.

One of the key assumptions on which the existing mine offset is based is that "*the black colour of the dust; its acid generating properties; and, nitrogen content (from explosives) will significant alter and reduce ecosystem functioning particularly in freshwater and quartz gravel patch ecosystems. The impact of the dark, sulphide- and nutrient-rich ore dust on the unique micro-flora and habitats on the Gamsberg [Mountain] is unclear, but is assumed to be detrimental, even at relatively low concentrations or 20 mg/m^2/day (10% above background rates). The quartz patches appear to derive their unique characteristics from the reflective nature of the white quartz. Any acidification or nutrient input is likely to be detrimental owing to the minimal buffering capacity in these systems.*" (Botha *et al.* 2013). Although most of the dust generated by the Smelter Project during operation will comprise $PM_{2.5}$ that will be emitted from the stacks rather than comprising black mine dust, the dust deposition thresholds on which the existing offset is based (i.e. 20 and 50 mg/m^2/day) are retained in this biodiversity assessment of the proposed Gamsberg Smelter Project and remain the fundamental premise for evaluating the proposed Smelter Project impacts of dust on succulent vegetation .

Of particular relevance to the proposed Gamsberg Smelter Project is the calcrete gravel plains habitat which is considered irreplaceable. There are three large patches in the vicinity of the proposed Gamsberg Smelter infrastructure; one located south of the SLF and two to the east of the proposed Gamsberg Smelter Plant and a few other small patches in the area (see Figure 3). Under the mine offset, 20 ha of calcrete gravel patches were quantified in the mine footprint and a further 384 ha indirectly impacted by the dust deposition zones, totalling 404 ha that needed to be offset (Botha *et al.* 2013). When taking into account a multiplier, a total of 1 732 ha of calcrete gravel patches were quantified as needing to be offset (Botha *et al.* 2013) to compensate for the 404 ha that was predicted to be impacted by the mine. However, the report noted that, based on its irreplaceability, this habitat type could not be offset (i.e. insufficient area of this habitat remains in the landscape to be secured as an offset). The offset report (Botha *et al.* 2013) recommended that residual impacts on terrestrial habitat units such as calcrete gravel patches and fine-grained plateau quartz patches of the Aggeneys gravel vygieveld that cannot be technically offset could be compensated for by other protection measures.

Table 2. Gamsberg Mine offset summary table indicating the quantification of habitat units for offsetting (but excluding multipliers used to determine the total offset requirements)

Vegetation Types; Habitat units and Conservation status	Mine footprint (a)	Dust Deposition (b)		Groundwater Drawdown (c)	Extent of Impact (d)
		50 mg/m²/day	20 mg/m²/day		
Aggeneys Gravel Vygieveld					
Mountain plateau; Constrained (VU)	123.2	58.5	117.1	280.8	181.7
Plateau quartz gravel; Irreplaceable (VU)	10.2	39.5	1.8	98.5	51.5
Plateau quartz gravel (fine grain); Irreplaceable (VU)			49.1		49.1
Plains quartz gravel; Irreplaceable (VU)	115.9	179.9	110.9	325.5	406.7
Plains quartz gravel intermediate; Constr. LC		56.5	231.0	240.4	56.5
Plains feldspar gravel; Constrained LC		17.4	73.8		91.2
Plains rocky; Constrained LC	71.8	160.6	559.0	237.6	232.5
Bushmanland Inselberg Shrubland					
Mountains; Flexible LC	535.4	335.5	751.3	1 314.5	871.0
Bushmanland Arid Grassland					
Flat sandy plains; Flexible LC	447.5	1 947.0	2 083.6	3 038.3	2 394.5
Hummocky sandy plains; Flexible LC	17.2	316.8	447.4	0.0	334.0
Calcrete gravel plains; Irreplaceable EN	20.3	154.1	229.4	44.6	403.7
Bushmanland Sandy Grassland					
Mobile sandy dunes; Flexible LC		5.3	29.6	18.1	5.3
Easten Gariep Plains Desert					
Plains Rocky; Flexible LC			252.1	120.7	
Bushmanland Inselberg Succulent Shrubland					
Southern Slopes; Irreplaceable (VU)	58.1	40.3	133.4	246.0	98.4
Azonal Habitats					
Kloof; (Irreplaceable)	27.8			148.9	176.7
Freshwater springs & Head-water Seep; (Irreplaceable)	-			-	-
River (Wash with sub-surface flow); Flexible LC	11.9			1 010.2	1 022.1
Wash; (Constrained)	39.9	442.4	928.9	276.5	482.3
TOTAL IMPACTED AREA (ha)					**6 857.1**

(a) Mine footprint includes pit, waste rock dumps, tailings, explosives magazine, plant, dams, administrative buildings, buffers on previous, roads and road buffers.
(b) Dust deposition is modelled extent of 50 mg/m²/day and 20 mg/m²/day. Habitats where dust exceeds 25% (50 mg/m²/day) of normal baseline are considered significantly impacted, similarly habitats where a high proportion of available habitat is affected by the 20 mg/m²/day dust zone.
(c) Groundwater drawdown based on the extent of the 10m drawdown after 100 years.
(d) Extent of Impact = sum of areas of affected habitats. (Note: Above areas exclude overlap and can be added)
LC – Least Concern; VU – Vulnerable; (VU) - VU implied by level of threat; EN – Endangered habitat.

Key to shading:	Habitat affected by respective impact	High proportion of available habitat affected	Very high proportion of available habitat impacted

(Source: Botha *et al.* 2013)

Towards meeting its offset obligations, BMM has purchased four properties/farms with a total of approximately 21,700 ha in the area around Gamsberg to offset the various habitat units impacted by the Gamsberg Zinc Mine. The four offset properties secured to date was proclaimed as a Protected Area under the National Environmental Management: Protected Area Act, 2003 (Act No. 57 of 2003) (NEMPA) on 5 August 2019 as the Gamsberg Nature Reserve, a Northern Cape Provincial Reserve. A management plan as required by the NEMPA is currently being compiled by the Department of Environment and Nature Conservation (DENC). The second time period to secure an additional three farms has been extended by the implementing parties of the Biodiversity Offset Agreement until 1 April 2024.

The context of the Gamsberg Zinc Mine offset is relevant to the proposed Gamsberg Smelter Project as a key potential issue is whether the direct and indirect residual impacts on biodiversity of the construction and operation of the smelter, SLF and associated infrastructure (after mitigation is implemented) may extend beyond the original area of residual impact used to determine the Gamsberg Zinc Mine Biodiversity Offset. If the residual impacts of the proposed Gamsberg Smelter Project remain within the modelled areas used as the basis for calculating the Gamsberg Zinc Mine Biodiversity Offset requirements, then an argument can be made that no additional offset would be required. Alternatively, if significant residual impacts of the proposed Gamsberg Smelter Project occur outside of the 20 and 50 mg/m^2/day modelled dust deposition areas (or groundwater drawdown area) then an additional offset could be required.

Despite adopting this approach as a framework should significant residual impacts be identified, strict adherence to the mitigation hierarchy (i.e. the need to avoid and minimise impacts prior to considering the need for offsets) remains the primary focus of the approach followed in this study, in line with the NEMA principles. That is, the loss of irreplaceable habitats such as the calcrete gravel patches, with associated range-restricted flora, still requires a ‘risk-averse and cautious’ approach, underlining the primary need to avoid loss of biodiversity, irrespective of whether these irreplaceable habitats fall within the existing residual impact area of the Gamsberg Zinc Mine.

Unfortunately, there has been insufficient monitoring of the mine’s impacts on vegetation to date to confirm if the calcrete gravel patches have been, or are being, affected by the mine dust. Therefore, it remains uncertain whether the original assumptions about the predicted influence of mine dust on succulent plants in the modelled 20 mg and 50 mg/m^2/day dust deposition areas on which the offset was largely based are valid or not. That is, although the Gamsberg Zinc Mine Biodiversity Offset has assumed these ‘irreplaceable’ areas and associated succulents will be ‘lost’ as a consequence of dust deposition from mining; this may not be the case. Given the uncertainty of the actual mine impacts this underlines the need for a precautionary approach and to follow the mitigation hierarchy to prioritise avoidance and minimisation of impacts. Therefore, the current ecological assessment of the proposed Gamsberg Smelter Project must consider the additional air quality impacts which may compound the negative dust impacts of mining on vegetation irrespective of whether the potentially affected area has been accounted for in the mine offset.

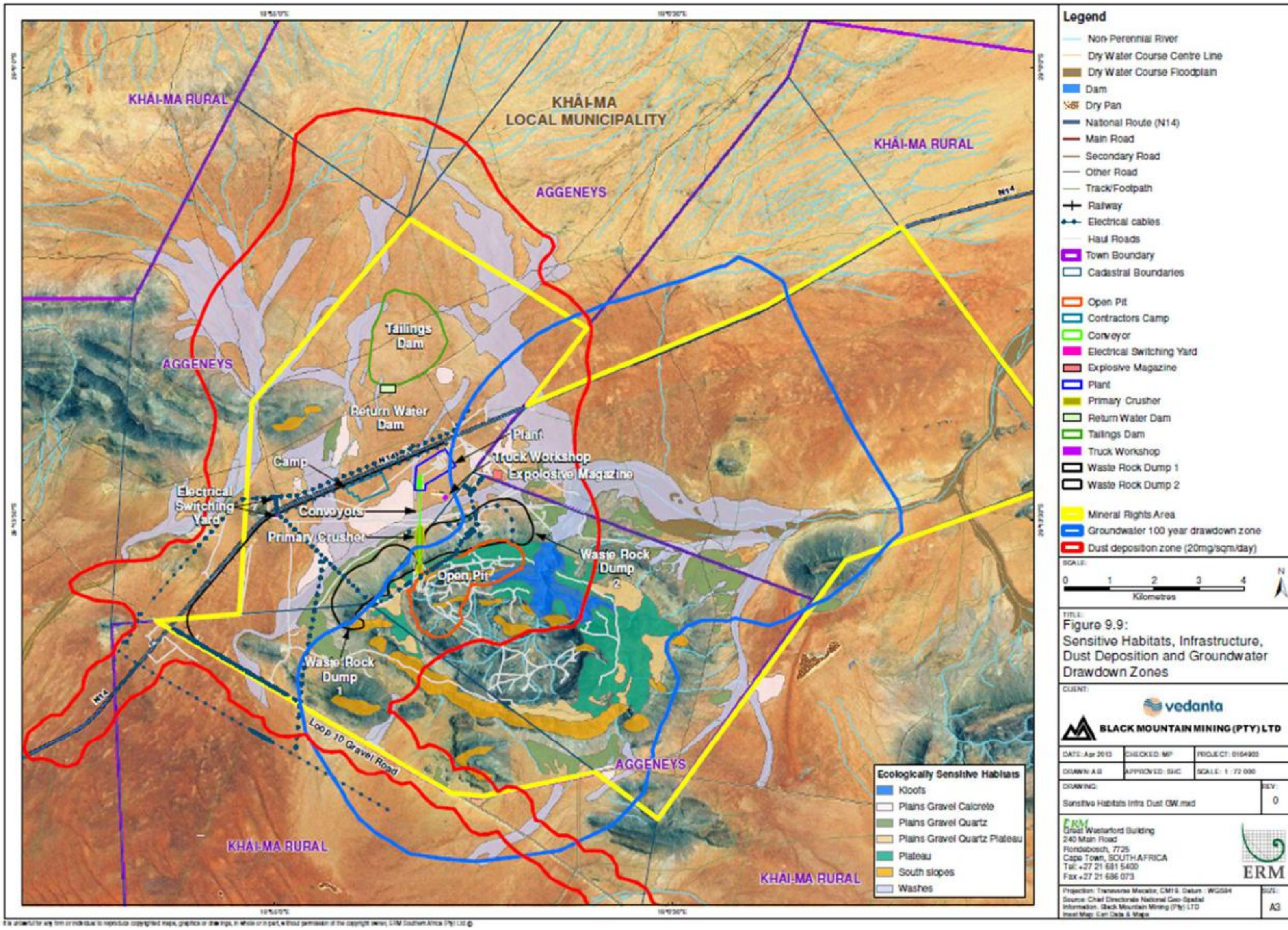


Figure 4. Map from EIA 2013 (Botha *et al.* 2013) showing the areas on which the mine offset was calculated. Note: the existing Gamsberg Mine Biodiversity Offset included all habitats within the red line (20 mg/m^2/day) and within the blue line (the modelled groundwater drawdown zone)

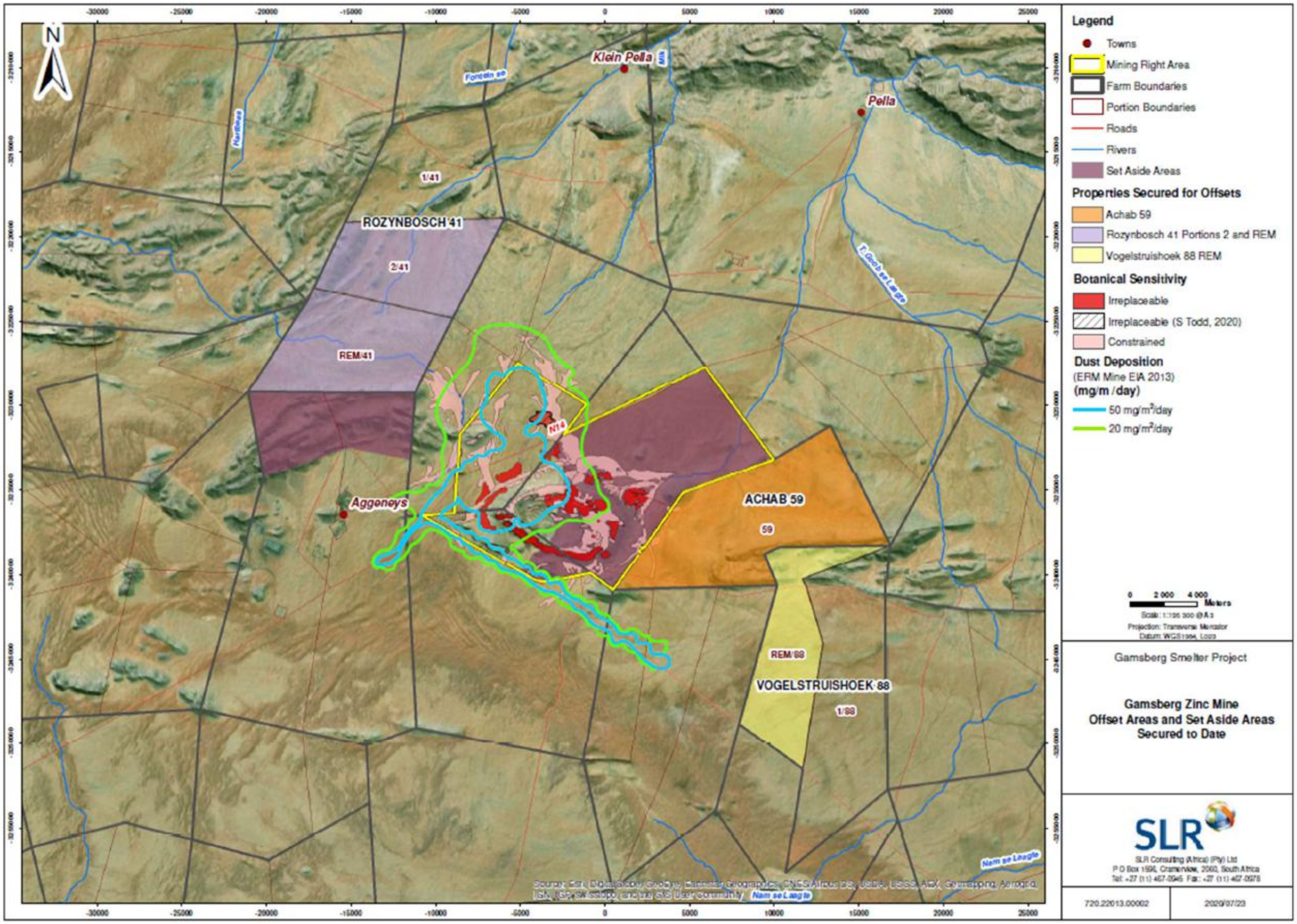


Figure 5. Map of Gamsberg Mine Offset and Set Aside areas secured to date showing the Gamsberg Zinc Mine dust deposition zones used to determine the offset requirements

3.4 Air Emissions Modelling Study

3.4.1 Background to Existing Air Emissions

Predictions of air quality impacts from the proposed Gamsberg Smelter Project require an understanding of the emission sources from the existing mining activities. Existing sources of air emissions from the Gamsberg Zinc Mine comprise:

- Particulate matter (PM) emissions from existing mining activities, specifically from materials handling activities, vehicle entrainment and windblown dust from storage piles and tailings storage facilities;
- Primary and secondary pollutants from vehicle exhaust emissions (not modelled), where:
    - Primary pollutants are those emitted directly into the atmosphere and comprise carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbon compounds (HC), sulphur dioxide (SO_2), oxides of nitrogen (NOx/NO_2) and particulate matter (PM); and
    - Secondary pollutants are formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. These include nitrogen dioxide (NO_2), photochemical oxidants (e.g. ozone), hydrocarbons (HC), sulphuric acid, sulphates, nitric acid and nitrate aerosols.
- Other fugitive dust sources resulting from:
    - Vehicle entrainment of dust from local paved and unpaved roads, and wind erosion from open areas, dependent on the number of vehicles using the roads and on the silt loading on the roadways; and
    - Windblown dust generated from natural and anthropogenic sources. This is influenced by wind speed necessary to mobilise dust; soil properties such as texture, moisture content and vegetation cover and topography.

These sources of emissions will have already altered, and will continue to alter, the baseline context of the proposed Gamsberg Smelter Project, especially the generation of dark coloured dust from the mine, and which is expected to further compound the air quality impacts. The scope of the air quality modelling study undertaken for the proposed Gamsberg Smelter Project EIA is set out below, the results of which have been used to inform the findings of this ecological assessment.

3.4.2 Smelter Project Air Emissions

An emissions inventory was compiled that identified the potential contaminants that would be emitted by the various proposed Gamsberg Smelter Project components (Airshed, 2020). While certain contaminants such as copper, cadmium, manganese, mercury, and arsenic will be present during the smelter processes, these were not modelled as they will be contained in the various products and wastes and not emitted through the stacks. Simulations were undertaken to determine particulate matter (PM_{10} and $PM_{2.5}$) deposition; NO_2, and SO_2 ground level concentrations, and lead and zinc deposition from project infrastructure and activities.

Note: Modelling did not include contaminants from the Jarofix that will be disposed of on the secured landfill facility as it will have a moisture content of between 30% and 40% and, since it solidifies to a hard concrete-like substance, it was considered unlikely to result in any dust emissions during disposal (Airshed 2020). The reader is referred to this air quality assessment for more information on the modelling parameters and outputs.

Air quality modelling outputs were generated for: i) different emissions for the proposed Gamsberg Smelter Project, and ii) cumulative dust emissions from the existing Gamsberg Zinc Mine and proposed Gamsberg Smelter Project combined. Although showing a similar pattern, the modelled outputs for dust deposition differ between the original modelling done for the EIA (DDA 2013) and that generated by Airshed for reasons summarised in Table 3.

Modelling outputs for each of the modelled air quality emissions was compared to available thresholds or critical loads / values of particulates and gaseous emissions for vegetation based on information from internet sources, as summarised in

Table **4**.

- **Particulates**: modelling of particulate fallout/deposition (representing PM_{10}, $PM_{2.5}$ and Total Suspended Particles (TSP)) was done for three scenarios with varying degree of control of emissions (i.e. no mitigation, and 75% and 90% Control Efficiency (CE)). Thresholds used to compare against model outputs for particulates were selected to be the same as those used for the Gamsberg Zinc Mine EIA and offset determination i.e. 50 mg/m^2/day and 20 mg/m^2/day (see Section 3.3). This allows direct comparison of the Airshed modelled outputs for dust fallout from the proposed Gamsberg Smelter Project with the modelled output for the Gamsberg Zinc Mine to compare the predictions, and determine if the potential dust fallout from the proposed Gamsberg Smelter Project will have additional impacts on important vegetation or flora that are not already accounted for by the Gamsberg Zinc Mine existing Biodiversity Offset (Section 3.3). Modelled dust fallout outputs were also used to check if the proposed Gamsberg Smelter Project would impact on the current and/ or earmarked offset properties (see Section 6.4.2).
- **SO_2:** International critical values for annual SO_2 ground level concentrations on vegetation range between 10 and 30 µg/m^3 depending on the type of vegetation (CLRTAP 2017), with the most sensitive vegetation being lichens with a critical annual ground level concentration of 10 µg/m^3. For the purpose of determining vegetation impacts, modelling outputs of the proposed Gamsberg Smelter Project were generated for annual concentrations of 1, 2 3, 5 and 10 µg/m^3. Annual concentrations of 5 and 10 µg/m^3 are considered to be within conservative international standards given the uncertainty of potential impacts on vegetation in an arid region. Note: previous background daily concentrations of SO_2 recorded during pre-mining baseline surveys in the vicinity of the SLF and Smelter ranged from 3.64 to 6.78 ug/m^3 (SRK 2009) (equivalent to an annual concentration of 0.16 to 0.3 ug/m^3 at a conversion factor of 0.044).
- **NO_2**: International critical values for annual and 24 hour mean NO_2 ground level concentrations for vegetation range between 30 µg/m^3 or 75 µg/m^3, respectively (CLRTAP 2017). For the purpose of determining impacts on vegetation, daily and annual modelling outputs of the proposed Gamsberg Smelter Project were generated for lower thresholds of 10 and 12 µg/m^3 and 1 and 2 µg/m^3, respectively.
- **Zinc and Lead**: While no thresholds or critical loads are defined for zinc and lead deposition on vegetation, modelled outputs were compiled for various levels ranging from a minimum of 0.5 mg/m^2/day to 700 mg/m^2/year to understand potential impact areas.

The basis for the existing Gamsberg Zinc Mine offset is described further in Section 3.3 while the analysis of potential air quality impacts on vegetation is described in Section 6.2 with reference to the modelled air quality outputs. Cumulative impacts are discussed and assessed in Section 6.4.

Modelled outputs for dust deposition for the 20 mg/m^2/day and 50 mg/m^2/day deposition for the existing Gamsberg Zinc Mine only and for the mine and smelter produced by Airshed (2020) were different from those generated by the 2013 modelling used to determine the Gamsberg Zinc Mine

Biodiversity Offset. This was due to differences in the meteorological data used and some differences in the criteria as summarised in Table 3.

Table 3. Summary of differences between Air Emission Models used for Gamsberg Zinc Mine EIA (DDA 2013) and the proposed Smelter Project model (Airshed 2020)

DDA 2013	Airshed 2020
Meteorological data used: Pofadder for the period 2007-2009.	Meteorological data used: WRF data for a point extracted at site for the period 2016-2018.
High moisture ore (>4%) emission factor used for the quantification of emissions from the crusher.	More for the moisture provided as 0.4%. Low moisture ore (<4%) emission factor used for the quantification of crushing emissions.
50% control efficiency assumed on all transfer points.	Control efficiency for materials handling was only assumed at the crusher transfer point (50% for wetting and a further 30% for enclosure).
Mean weight of trucks assumed to be 320t and 32 trucks used to haul ore.	Provided that the trucks will be between 90t and 180t capacity. This equates to an average weight of between 120t and 240t and ~203 trips per day to move 10 Mtpa ore.
The silt content on the road was assumed to be 6.9%. this assumption was not qualified.	The silt content on the road was assumed to be 8.4% based on US EPA defaults.

Table 4. Summary of modelled air emissions, scenarios run and available vegetation thresholds

Parameter	Modelled outputs	Modelled maximum	Scenarios Run	Vegetation thresholds
Deposition (Fallout)				
PM	50 mg/m^2/day 20 mg/m^2/day	38,983 mg/m^2/day 9,745 mg/m^2/day 3,898 mg/m^2/day	Max daily dust deposition – refinery stacks and vehicle dust internal access roads (unpaved) (no mitigation) Max daily dust deposition – 75% CE Max daily dust deposition- 95% CE	20 and 50 mg/m^2/day used in mine offset calculations No standard thresholds available for vegetation. NAAQS standards for human health are 75 µg/m^2/day and 40 ug/m^2/day for PM_{10} and $PM_{2.5}$, respectively.
PM	5 mg/m^2/day 2 mg/m^2/day	10.5 mg/m^2/day	Max daily dust deposition – stacks only	
Zn & Pb	700 mg/m^2/year 350 mg/m^2/year 150 mg/m^2/year 50 mg/m^2/year	Pb=1135 mg/m^2/year Zn=1222 mg/m^2/year	Annual deposition (stacks only) (excludes mine dust on roads)	No standards or critical values available
Zn & Pb	150 mg/ m^2/month	Pb=237 mg/m^2/year Zn=241 mg/m^2/year	Monthly deposition (stacks only) (excludes mine dust on roads)	
Zn & Pb	5 mg/ m^2/day 0.5 mg/m^2/day	Pb=7.8 mg/m^2/year Zn=7.9 mg/m^2/year	Daily deposition (stacks only) (excludes mine dust on roads)	
Ground level concentrations				
SO_2 Annual concentrations	5 µg/m^3 10 µg/m^3	11 µg/m^3	Annual average ground level concentrations (stacks)	10 µg/m^3 lichens; 20 µg/m^3 semi-nat veg / forest; 30 µg/m^3 agri crops. (CLRTAP 2017)
NO_2 24-hour mean	10 µg/m^3 12 µg/m^3	23.5 µg/m^3	Highest daily ground level concentrations (stacks)	75 µg/m^3 (CLRTAP 2017)
NO_2 Annual concentrations	1 µg/m^3 2 µg/m^3	2.8 µg/m^3	Annual average ground level concentrations (stacks)	30 µg/m^3 (CLRTAP 2017))

Note: although outputs for zinc and lead were generated for the different levels indicated in this table, maps presented in this report are based on daily deposition for comparison with the daily dust deposition levels.

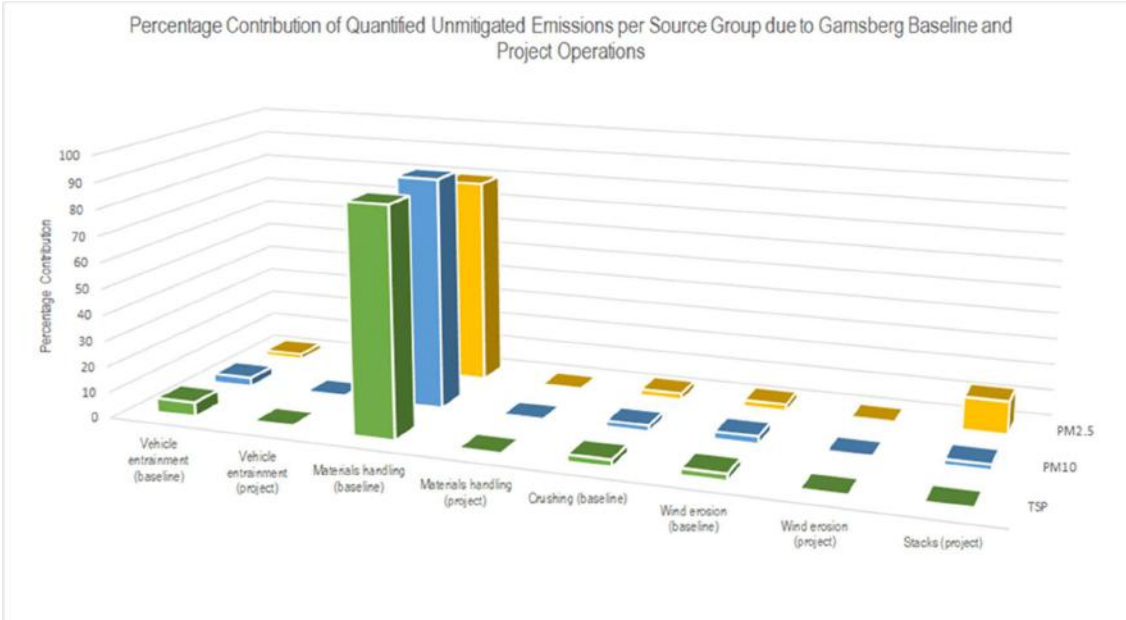
A summary of the relative contribution of the various modelled particulate emissions from the Gamsberg Zinc Mine and proposed Gamsberg Smelter Project is illustrated below in Figure 6. Comparisons of modelled dust deposition areas for the Gamsberg Zinc Mine only, versus mine plus proposed Gamsberg Smelter Project, are shown in Figure 7 and Figure 8. It is clear that the 'materials handling' component of the existing mining operations (which comprises the 'baseline' state for this study) is the dominant source of particulate emissions and the contribution of the proposed Gamsberg Smelter Project ('project') to particulates is a small proportion of that generated by the mine. The main findings of the air quality study (Airshed 2020)[2] for the proposed Gamsberg Smelter Project shows that the simulated $PM_{2.5}$ and PM_{10} contributions due to the combined Gamsberg Zinc Mine ('baseline') combined with proposed Gamsberg Smelter Project ('project') operations are similar to those generated by the existing Gamsberg Zinc Mine only. Although not specifically relevant to vegetation, the modelling showed that the highest simulated lead, NO_2 and SO_2 concentrations due to project operations would be in compliance with the National Ambient Air Quality Standards (NAAQS) and that the maximum daily dust deposition due to project operations are predicted to be

[2] Note: the Airshed report is focussed on compliance of model outputs with national air quality standards in relation to social receptors around the Smelter. Modelled air emission outputs for use in this flora and fauna study were provided separately to inform the assessment of impacts.

within the National Dust Control Regulations (NDCR) at all sensitive social receptors within the study area. No NAAQS standards are applicable to zinc.

The modelling results are not interpreted in the Airshed 2020 report in terms of risks to vegetation or flora and consequently, the potential impacts of the air emissions resulting from the current project are investigated as part of this study. Airshed prepared a series of modelled outputs and output levels indicated in

Table **4** which have been used to inform the assessment of air quality impacts on vegetation and flora in Section 6.2.



	Vehicle entrainment (baseline)	Vehicle entrainment (project)	Materials handling (baseline)	Materials handling (project)	Crushing (baseline)	Wind erosion (baseline)	Wind erosion (project)	Stacks (project)
TSP	5.48	0.95	87.18	0.02	2.59	2.60	0.19	0.99
PM10	3.36	0.43	88.82	0.02	2.23	2.80	0.21	2.13
PM2.5	1.99	0.52	79.73	0.02	2.45	2.49	0.19	12.62

Figure 6. Percentage contribution of particulate emissions due to baseline and project operations (Airshed 2020)

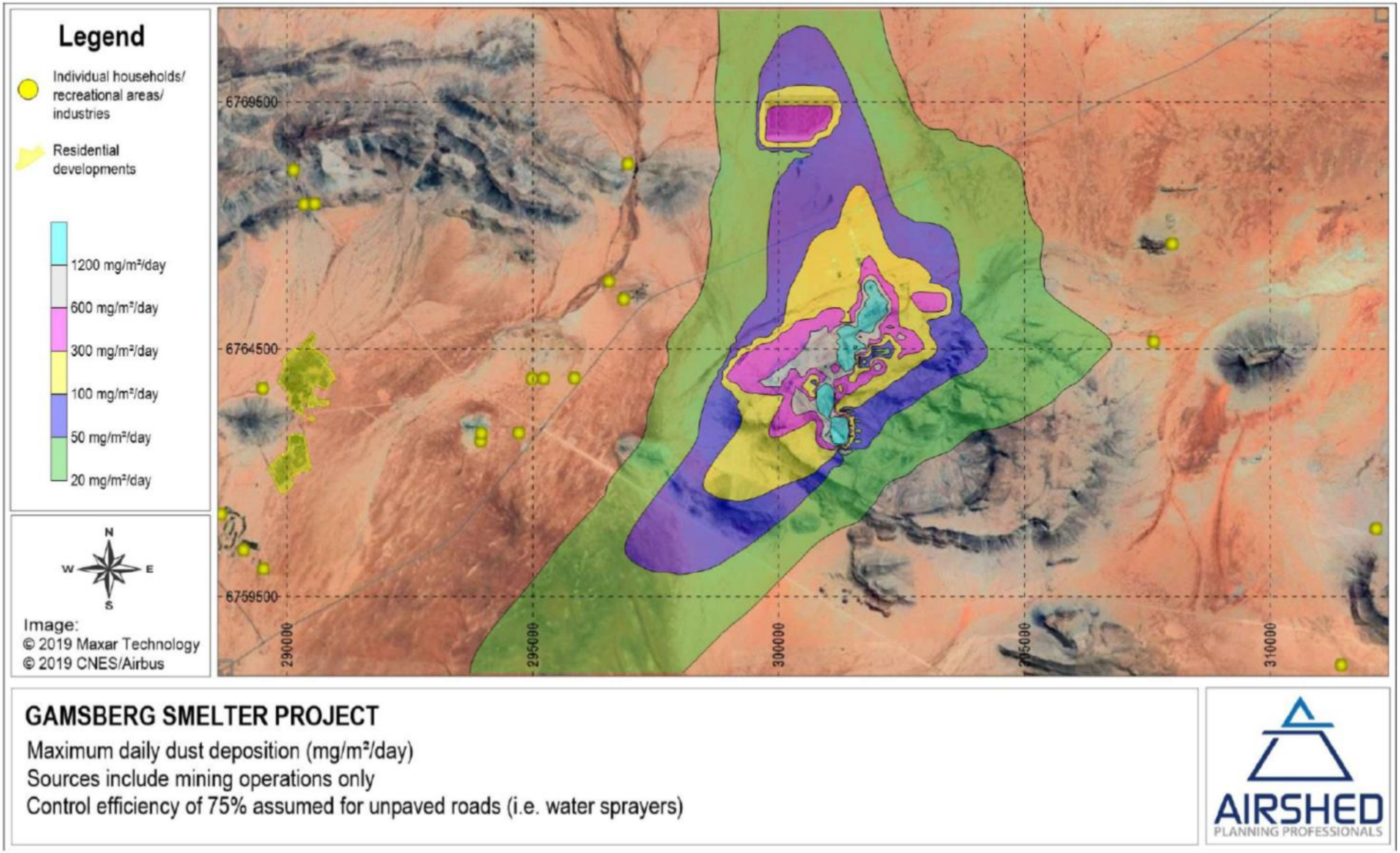


Figure 7. Map of remodelled maximum daily dust deposition for the Gamsberg mining operations only, without the contribution of the Smelter Project.

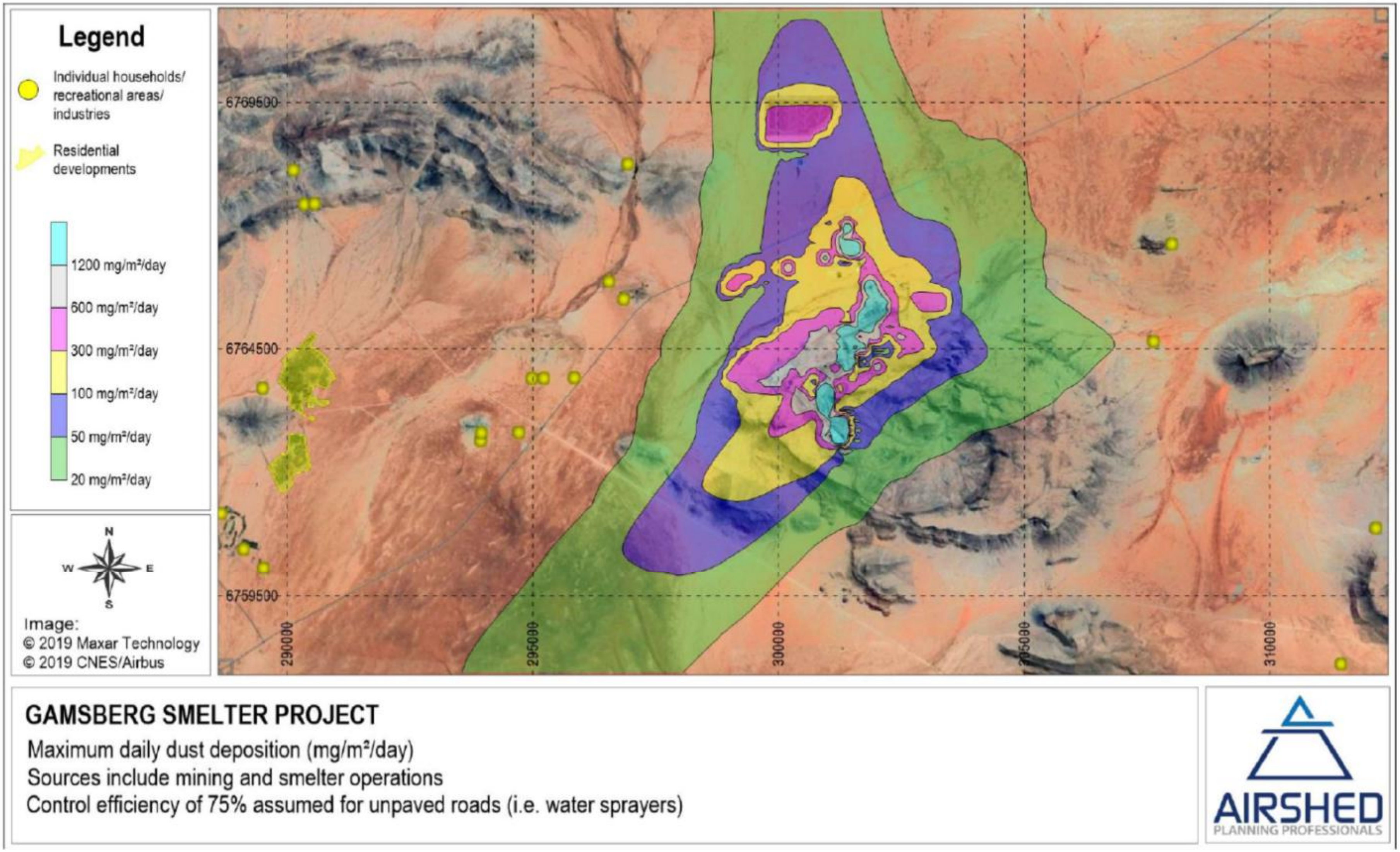


Figure 8. Map of remodelled maximum daily dust deposition for the Gamsberg mining operations and the Smelter Project operations combined

3.5 Groundwater Modelling Study

As the proposed Gamsberg Smelter Project could potentially have groundwater impacts due to leaching from the SLF into the groundwater, a groundwater modelling study was undertaken (SLR 2020a). The geohydrology study has been used to verify whether groundwater contamination could impact on vegetation. Potential contaminants identified and modelled in the geohydrology study were sulphate, sodium, lead, and antimony. The model results indicate that at the end of the operational phase (15 years), leachate would be of such small quantities, given the Type 1 liner required under the SLF, and would not influence groundwater levels. However, the model results showed that contaminants could enter into the groundwater aquifer at an approximate depth of 30 m below ground level (mbgl) and that these contaminants could extend in a plume at distances between 570 m (lead) and 840 m (antimony) from the SLF over a 15 year period. Over a longer period of 50 years the contaminants could extend over a wider area. No impacts on the aquifer and spring of the Gamsberg Inselberg are expected as the regional groundwater flow at the SLF location is away from the inselberg towards the plains and there is a geological structure that acts as a barrier to groundwater flow (and contamination) towards the inselberg. Although groundwater contamination can and does impact vegetation, particularly deep-rooted trees, vegetation of the area of influence is predominantly shallow-rooted and there are no groundwater-dependent plants present that are expected to be affected by groundwater contamination.

4 BASELINE DESCRIPTION OF THE RECEIVING ENVIRONMENT

4.1 Vegetation Types & Plant Communities

4.1.1 Broad-Scale Vegetation Types

Although there are several national vegetation types in the broader study area (Figure 9), only Bushmanland arid grassland and Aggeneys gravel vygieveld are present within the proposed Gamsberg Smelter Project's area of influence. Bushmanland arid grassland is an extensive vegetation type; the second most extensive vegetation type in South Africa, occupying an area of 45,478 km^2. It extends from the study area around Aggeneys in the east to Prieska in the west. It is associated largely with red-yellow apedal (without structure), freely drained soils, with a high base status and mostly less than 300 mm deep. Due to the arid nature of the unit, which receives between 70 and 200 mm annual rainfall, it has not been significantly impacted by intensive agriculture and more than 99% of the original extent of the vegetation type is still intact. Mucina and Rutherford (2006) list six endemic species for the vegetation type, which is a relatively low number given the extensive nature of the vegetation type.

Aggeneys gravel vygieveld occurs on the foothills and peneplains of inselbergs in northern Bushmanland scattered between Pofadder and Aggeneys and a little further westward to the edges of the Namaqualand granite hill ridges. This unit occurs on flat or slightly sloping plains with a distinctly white surface layer of quartz pebbles on reddish soils. It supports sparse low-growing vegetation dominated by small to dwarf leaf-succulents of the families *Aizoaceae, Crassulaceae, Euphorbiaceae, Portulaceae* and *Zygophyllaceae*. A number of different variants have been identified associated with different substrate conditions. Although this is not a threatened vegetation type, it has an extent of only 62 km^2 and reportedly (Mucina & Rutherford 2006) has 17 endemic species which is a very high number for such a small vegetation unit. This unit is considered to represent an outlier of the Succulent Karoo Biome, embedded within the Nama Karoo. Due to the presence of numerous endemic and specialised species associated with this vegetation type, it is considered to represent irreplaceable habitat. The presence of these local endemic flora species is a key basis for the identification of the entire Gamsberg area as a Critical Biodiversity Area (CBA) (see Section 4.3).

4.1.2 Fine-Scale Habitats & Plant Communities

Desmet (2013) identified and delineated a number of habitat units (Figure 10). In the Aggeneys gravel vygieveld vegetation type. Desmet (2013) mapped six habitat units: four occurring in the Gamsberg Mine study area are mountain plateau, plains quartz gravel patches; plateau quartz gravel patches and plains intermediate quartz gravel patches, and two that occur to the east of the study area include feldspar gravel patches and rocky plains.

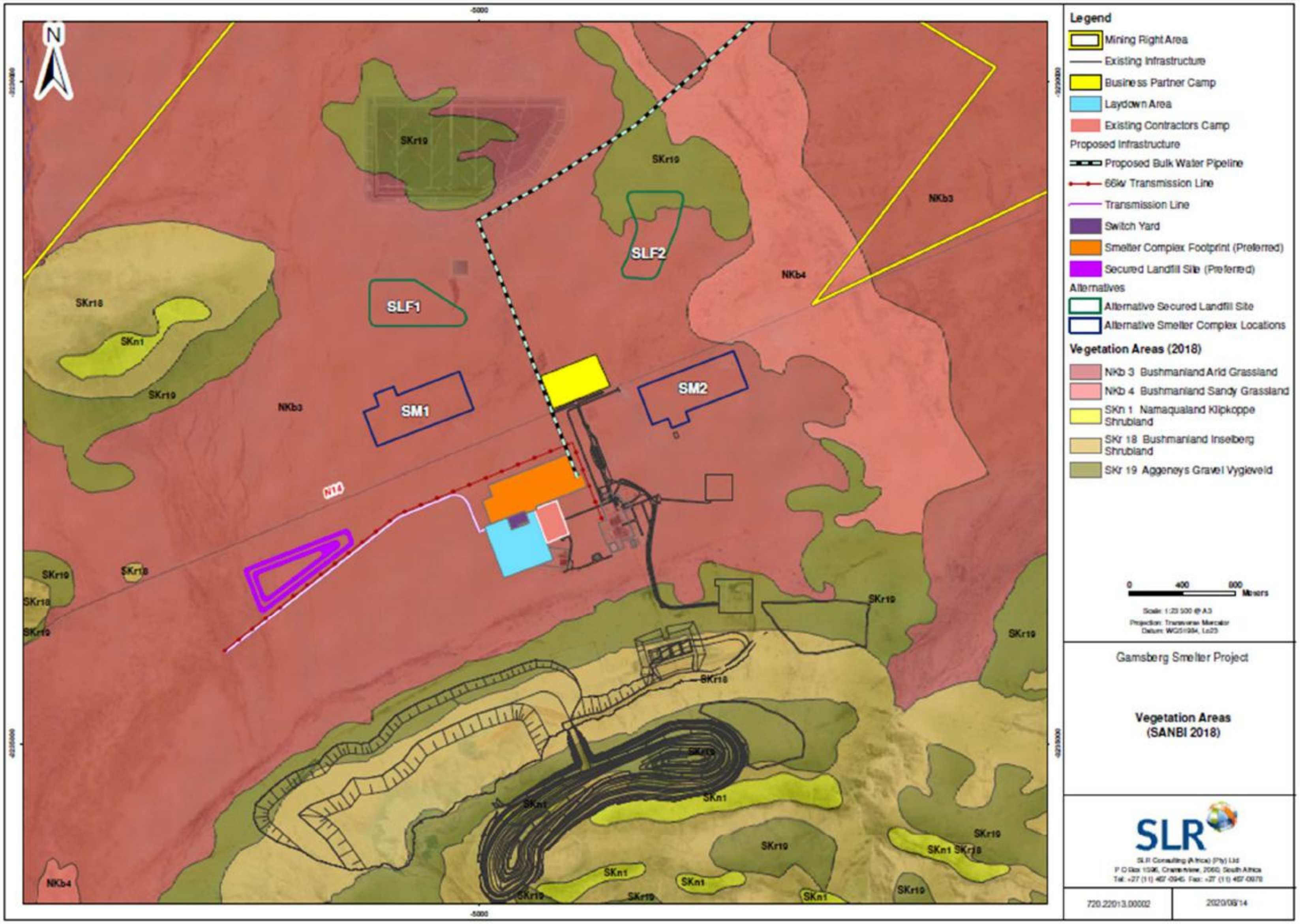


Figure 9. Broad-scale overview of the vegetation in and around the Gamsberg Zinc Mine. The vegetation map is based on the 2018 National Vegetation Map (SANBI, 2018).

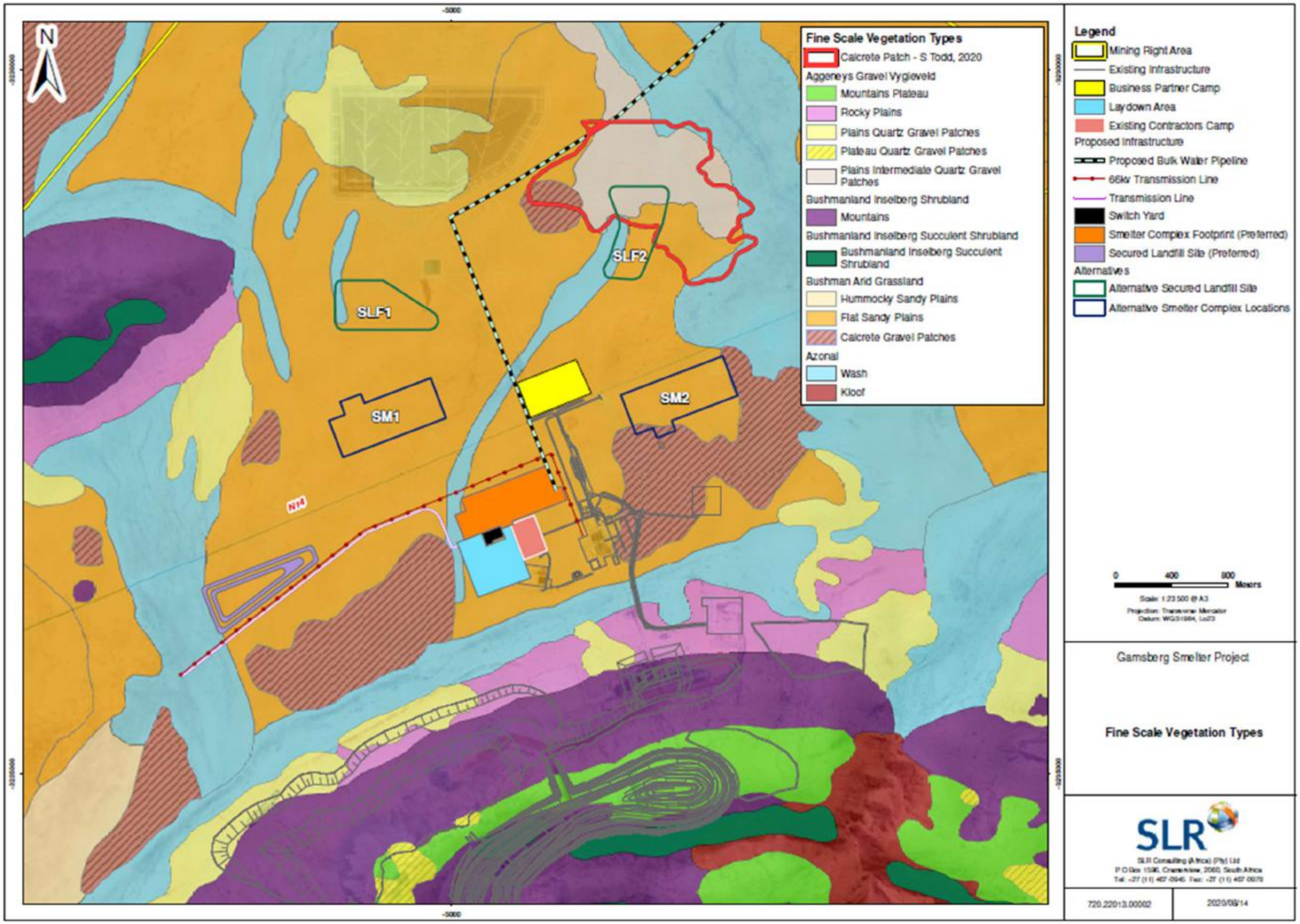


Figure 10. Fine-scale Vegetation Types in the Gamsberg Area. Note the hatched calcrete gravel patches to the east and west of the Smelter.

The plains quartz gravel patches habitat occurs in the vicinity of the proposed Gamsberg Smelter Project although the smelter site itself comprises sandy plains habitat (Figure 11). According to Desmet (2013) the surface of quartz gravel patches is characterised by a fairly uniform and dense layer (lag) of small quartz pebbles with rock and boulders absent or in low density. Quartz patches can be divided into plateau patches or fine-grained quartz patches with a dense pebble covering of often very small (<5 mm diameter) and brilliant white pebbles. Plains quartz patches occur mainly on the lower foot slopes of larger inselbergs; and Intermediate Quartz patches appear physically similar to the other quartz patches but are devoid of any of the characteristic plant species. Quartz gravel patches are always found in association with quartz or quartzite rocks. While a number of succulent plant species occur in this habitat unit, the only species restricted to plains quartz gravel patches and which do not occur on the plateau are the diminutive annual succulent, *Mesembryanthemum inachabense*, and "the multi-bodied polyploid form" of *Conophytum angelicae* (Desmet 2013).

Figure 11. Plains Sandy Flats habitat in the main footprint area of the preferred Smelter Site (SM3).

Desmet (2013) identified three different habitat units within the Bushmanland Arid Grassland vegetation type namely, plains sand flats (Bushmanland Flat Arid Grassland), plains hummocky (Bushmanland Hummock Arid Grassland) and plains gravel calcrete. Apart from the plains gravel calcrete, these habitat units do not have diverse plant communities and generally contain few species of conservation concern.

The plains gravel calcrete patches (Figure 12) are considered unique and contain several taxa not found elsewhere including *Brownanthus divaricata, Drosanthemum hispidum, Kleinia longiflora, Pteronia divaricata, Cucumis rigidus, Euphorbia gariepina, Euphorbia mauritanica, Euphorbia spinea, Sarcocaulon crassicaule, Avonia albissima, Ceraria fruticulosa, Zygophyllum cf. decumbens* as well as several endemic species restricted to these calcrete gravel patches such as *Titanopsis hugo-schlechteri, Crassula mesembrianthemopsis, Anacampseros bayeriana, Lithops julii subsp. fulleri var. fulleri,* and *Ruschia aff. divaricata* (Desmet 2013).

Figure 12. Plains calcrete gravel north of the N14, in the vicinity of SLF Alternative 2 and the bulk water pipeline. Although these calcrete gravel patches appear relatively devoid of vegetation, they support numerous endemic species. Note: this calcrete gravel patch was not previously surveyed in previous studies for the Gamsberg EIA and was defined as a much smaller area in previous mapping by Desmet (2013).

4.1.3 Indigenous Flora Species

Typical and dominant species in the proposed Gamsberg Smelter Complex footprints include *Eriocephalus* sp., *Pteronia unguiculata*, *Rhigozum trichotomum*, *Stipagrostis brevifolia*, *S.obtusa* and *Ebracteola fulleri*. Notable species confirmed during the January 2020 survey comprised six species, all protected in the Northern Cape, summarised in Table 5 and shown in Figure 13 and Figure 14. Several individuals of three of these species were commonly found in the selected Smelter and SLF footprint: *Euphorbia braunsii, Hoodia gordonii* and *Aloidendron dichotomum* (Quiver Tree), none of which are considered uncommon or rare in the proposed Gamsberg Smelter Project area. The development would be highly unlikely to compromise the local populations of these species as they are widespread outside the likely area of influence of the mine. Locations of plant species of conservation concern are contained in Appendix 3.

Table 5. Plant species confirmed during the January 2020 survey in the Smelter Project area and alternative sites

Species	Status	Habitat Unit	Location
Titanopsis hugo-schlechteri	NC Protected	Calcrete Gravel Plains	SLF 2
Avonia papyracea subsp. *papyracea*	NC Protected	Calcrete Gravel Plains	SLF 2
Boscia foetida subsp. *foetida* (Stink Shepherd's Tree)	NC Protected	Calcrete Gravel Plains	SLF 2
Euphorbia braunsii	NC Protected	Flat Sandy Plains	SLF 3, SM 3
Hoodia gordonii	Data Deficient NC Protected	Flat Sandy Plains	SLF 3
Aloidendron dichotomum (Quiver Tree)	Vulnerable NC Protected	Flat Sandy Plains	SLF 3 (many) SLF 1 (few)

Figure 13. *Titanopsis hugo-schlechteri* and *Avonia papyracea* subsp. *papyracea* observed at SLF Alternative 2 (SLF2). This indicates this is a sensitive habitat that should be considered unsuitable for development.

Figure 14. Notable species observed within SLF Alternative 3 includes *Hoodia gordonii*, *Euphorbia braunsii* and *Aloidendron dichotomum* (VU).

Earlier surveys in the calcrete gravel patches to the south of the SLF and to the east of the proposed location of the Smelter plant by Desmet (2013) recorded the following flora species: *Titanopsis hugo-schlechteri, Crassula mesembrianthemopsis,* and *Lithops julii* subsp. *fulleri;* all endemic to the region and restricted to calcrete gravel patches. Additional species confirmed in the vicinity of the smelter to the east include *Avonia quinaria subspp. alstonii* in quartz gravel plains, and *Euphoriba friedrichiae. Titanopsis hugo-schlechteri* and *Crassula mesembrianthemopsis* are considered Vulnerable and have an estimated distribution range of less than 1000 km^2. They are under threat from livestock grazing (Desmet 2013). Calcrete gravel patches are considered to be of high conservation concern and evaluated as irreplaceable due to the presence of restricted-range species.

4.1.4 Alien Plants

Alien plant species abundance at the site was low. This can partly be ascribed to the prevailing drought conditions as well as an actual low abundance of such species within the site. The major species of concern in this regard is the alien invasive tree *Prosopis glandulosa* and its' various hybrids which is common in the area and tends to invade along drainage lines and more generally in areas with deeper soils. This species is not seen as a current threat in the immediate area of the Gamsberg Zinc Mine, but as it is adept at taking advantage of disturbance, it is likely to invade cleared or disturbed parts of the site over time.

4.2 Faunal Communities

4.2.1 Mammals

The mammalian community at the project site is likely to be of moderate diversity. Although more than 50 species of terrestrial mammals are known from the wider area, the habitat diversity of the project site is low and would not support a very wide range of mammals. Species that can be confirmed present in the proposed Gamsberg Smelter Project area based on camera trapping and previous site visits to the area include Leopard (*Panthera pardus*), Caracal (*Caracal caracal*), Black-backed Jackal (*Canis mesomelas*), African Wildcat (*Felis silvestris*), Cape Fox (*Vulpes chama*), Chacma Baboon (*Papio ursinus*), Rock Hyrax (*Procavia capensis*), South African Ground Squirrel (*Xerus inauris*), Steenbok (*Raphicerus campestris*), Common Duiker (*Sylvicapra grimmia*), Springbok (*Antidorcas marsupialis*), Gemsbok (*Oryx gazella*), Cape Porcupine (*Hystrix africaeaustralis*), Yellow Mongoose (*Cynictis penicillata*), Cape Grey Mongoose (*Herpestes pulverulentus*), Small-spotted Genet (*Genetta genetta*), Striped Polecat (*Ictonyx striatus*), Cape Hare (*Lepus capensis*), Smiths's Red Rock Rabbit (*Pronolagus rupestris*), Springhare (*Pedetes capensis*), Aardvark (*Orycteropus afer*), Aardwolf (*Proteles cristata*), Round-eared Elephant Shrew (*Macroscelides proboscideus*), Western Rock Elephant Shrew (*Elephantulus rupestris*), Namaqua Rock Mouse (*Aethomys namaquensis*), Pygmy Rock Mouse (*Petromyscus collinus*) and Hairy-footed Gerbil (*Gerbillurus paeba*) (Figure 15 and Appendix 4). The open plains which characterise the majority of the proposed Gamsberg Smelter Project area are likely to be dominated by species associated with open hard or sandy ground such as various gerbils including the Hairy-footed Gerbil, Cape Hare, Steenbok, Cape Fox, Bat-eared Fox (*Otocyon megalotis*), Aardvark and Aardwolf. There are also burrows of Ground Squirrels and Yellow Mongoose at the site and these appear to be the most common fauna within the affected area.

No bats were observed during the January 2020 survey. A previous survey by GroundTruth (2013) which included mist-netting and bat acoustic monitoring detected only one bat - Darling's Horseshoe Bat (*Rhinolophus darling*) - classed as Least Concern by IUCN (IUCN 2017). Bats are likely to be restricted to the vicinity of the inselberg where they can shelter in rock crevices or caves and have access to water while some individuals may only fly over the gravel plains area for foraging.

Three Red-listed species have been confirmed or may occur in the broader area, the Black-footed cat (*Felis nigripes*) (Vulnerable), Brown Hyaena (*Hyaena brunnea*) (NT) and Leopard (*Panthera pardus*) (Vulnerable). Given the existing levels of anthropogenic disturbance at the site, it is not likely that these three species will remain active in close proximity to the Gamsberg Zinc Mine and the proposed Gamsberg Smelter Project footprint. However, leopard have been recorded at the Gamsberg kloof and Achab farm.

Figure 15. The Hairy-footed Gerbil (*Gerbillurus paeba*) is the most common small mammal observed in the study area.

4.2.2 Reptiles

Although reptile diversity in the broader area is high with as many as 60 species known from the area (ReptileMap 2020 http://sarca.adu.org.za/), a much smaller subset of these is likely to be present within the site (Appendix 5). A total of 24 species have previously been recorded from the site according to the previous studies conducted for the Gamsberg Zinc Mine ESIA (Groundtruth 2013). Species observed during the current field assessment or within the study area previously, are typical of the area and include Verrox's Tent Tortoise (*Psammobates tentorius verroxii*), Western Rock Skink (*Trachylepis sulcata sulcate*), Western Three-striped Skink (*Trachylepis occidentalis*), Namaqua Sand Lizard (*Pedioplanis namaquensis*), Spotted Desert Lizard (*Meroles suborbitalis*), Southern Rock Agama (*Agama atra*) and Plain Sand Lizard (*Pedioplanis inornata*) (Figure 16).

Figure 16. Some of the reptiles observed at the site include from top left, Verrox's Tent Tortoise, Western Three-striped Skink, Western Rock Skink and Variegated Skink

No snakes were observed during the January 2020 site visit, although species likely to occur include Black Spitting Cobra (*Naja nigricincta*) and Cape Cobra (*Naja nivea*). The Desert Mountain Adder (*Bitis xeropaga*) was confirmed in 2012 (GroundTruth 2013) and is a range-restricted endemics confined to the lower Gariep River and adjacent regions, and is restricted to rocky, mountainous habitat and therefore unlikely to occur on the flat sandy plains. Conditions at the time of the site visit were relatively poor for reptiles as a result of the prolonged drought that the area has been experiencing, and the depressing effect this is likely to have had on local reptile populations. There are only two Red-listed species recorded from the area, Good's Gecko (*Pachydactylus goodi*) (VU) and the Speckled Padloper (*Homopus signatus*) (VU).

4.2.3 Amphibians

Eight frog species are known from the area around the site (Appendix 6). This is likely an overestimate of the number of amphibian species present within the Gamsberg Inselberg where there is a spring and kloof. However, there is no natural perennial water in or near the open plains which characterise the current potential development areas of the proposed Gamsberg Smelter Project. The only species likely to be present within the affected area would be species that are relatively independent of water such as the Karoo Toad (*Vandijkophrynus gariepensis*) and the Paradise Toad (*Vandijkophrynus robinsoni*). The ephemeral drainage lines present in the area are likely to be the most important areas for amphibians, but given the extreme drought conditions which characterise the area, there are not likely to be any parts of the site that are of high importance for amphibians.

4.2.4 Avifauna

The most commonly recorded species at the site includes the Chat Flycatcher (*Melaenornis infuscatus*), Karoo Chat (*Cercomela schlegelii*), and Anteating Chat (*Myrmecocichla formicivora*). Other typical and characteristic species include Spike-heeled Lark (*Chersomanes albofasciata*) and Tractrac Chat (*Emarginata tractrac*). Although the near-threatened Karoo Korhaan (*Eupodotis vigorsii*) was observed in the area, it was not observed in close proximity to the proposed Gamsberg Smelter Project footprint. The near-threatened Sclater's Lark *Spizocorys sclateri* is also present in the area, but no observations were made in the vicinity of the current site. Raptors observed in the general area include the Endangered Martial Eagle *Polemaetus bellicosus,* Black-chested Snake-eagle *Circaetus pectoralis*, Verreaux's Eagle *Aquila verreauxii* and Jackal Buzzard *Buteo rufofuscus*, suggesting that large raptors are still relatively common in the area and are likely using the affected plains of the site for foraging. Although the endemic Red Lark *Calendulauda burra* (Red-listed as Vulnerable), is present in the wider area, it was not observed in close proximity to the site due to the lack of suitable red dune habitat near the Project Area.

Table 6. Relative abundance (birds/km) of bird species recorded along transects within the plains habitat at Gamsberg (12 transects between the N14 and the Gamsberg Mountain)

English name	Taxonomic name	Encounter Rate
Anteating Chat	*Myrmecocichla formicivora*	0.33
Barn Swallow	*Hirundo rustica*	0.33
Black-chested Snake-eagle	*Circaetus pectoralis*	0.17
Chat Flycatcher	*Melaenornis infuscatus*	0.83
Double-banded Courser	*Rhinoptilus africanus*	0.17
Jackal Buzzard	*Buteo rufofuscus*	0.17
Karoo Chat	*Emarginata schlegelii*	1.17
Pale-winged Starling	*Onychognathus nabouroup*	1.17
Pied Crow	*Corvus albus*	0.33
Rock Kestrel	*Falco rupicolus*	0.50
Rufous-eared Warbler	*Malcorus pectoralis*	0.33
Scaly-feathered Finch	*Sporopipes squamifrons*	0.17
Sociable Weaver	*Philetairus socius*	1.00
Southern Fiscal	*Lanius collaris*	0.50
Spike-heeled Lark	*Chersomanes albofasciata*	6.00
Tractrac Chat	*Emarginata tractrac*	1.67

Red-listed species which occur in the wider area include Martial Eagle (*Polemaetus bellicosus*) (Endangered), the endemic Red Lark (*Calendulauda burra*) (Vulnerable), Verreaux's Eagle (*Aquila verreauxii*) (Vulnerable), Lanner Falcon (*Falco biarmicus*) (Vulnerable), Secretarybird (*Sagittarius serpentarius*) (Vulnerable), and the near-endemic Sclater's Lark (*Spizocorys sclateri*) (Near-threatened). The Lanner Falcon (*Falco biarmicus*) has a high probability of occurring within the affected area, while Secretarybird has a low probably of occurrence, based on SABAP2 reporting. Verreaux's Eagles (*Aquila verreauxii*) are confirmed present on the Gamsberg Plateau with nesting sites present on the cliffs along the kloof. These species, including the Secretarybird (*Sagittarius serpentarius*), have large home ranges and are thus unlikely to be affected by the proposed Gamsberg Smelter Complex and SLF.

4.3 Critical Biodiversity Areas

A map of the Critical Biodiversity Areas (CBAs) in the proposed Gamsberg Smelter Project area compiled from the 2016 Northern Cape Critical Biodiversity Areas (CBA) dataset is depicted in Figure 17. CBAs are areas that have been identified as being essential for meeting biodiversity targets for the protection or retention of specific ecosystems. Two categories of CBAs are defined (CBA1 and CBA2), as well as Ecological Support Areas (ESAs) and Other Natural Areas (ONAs).

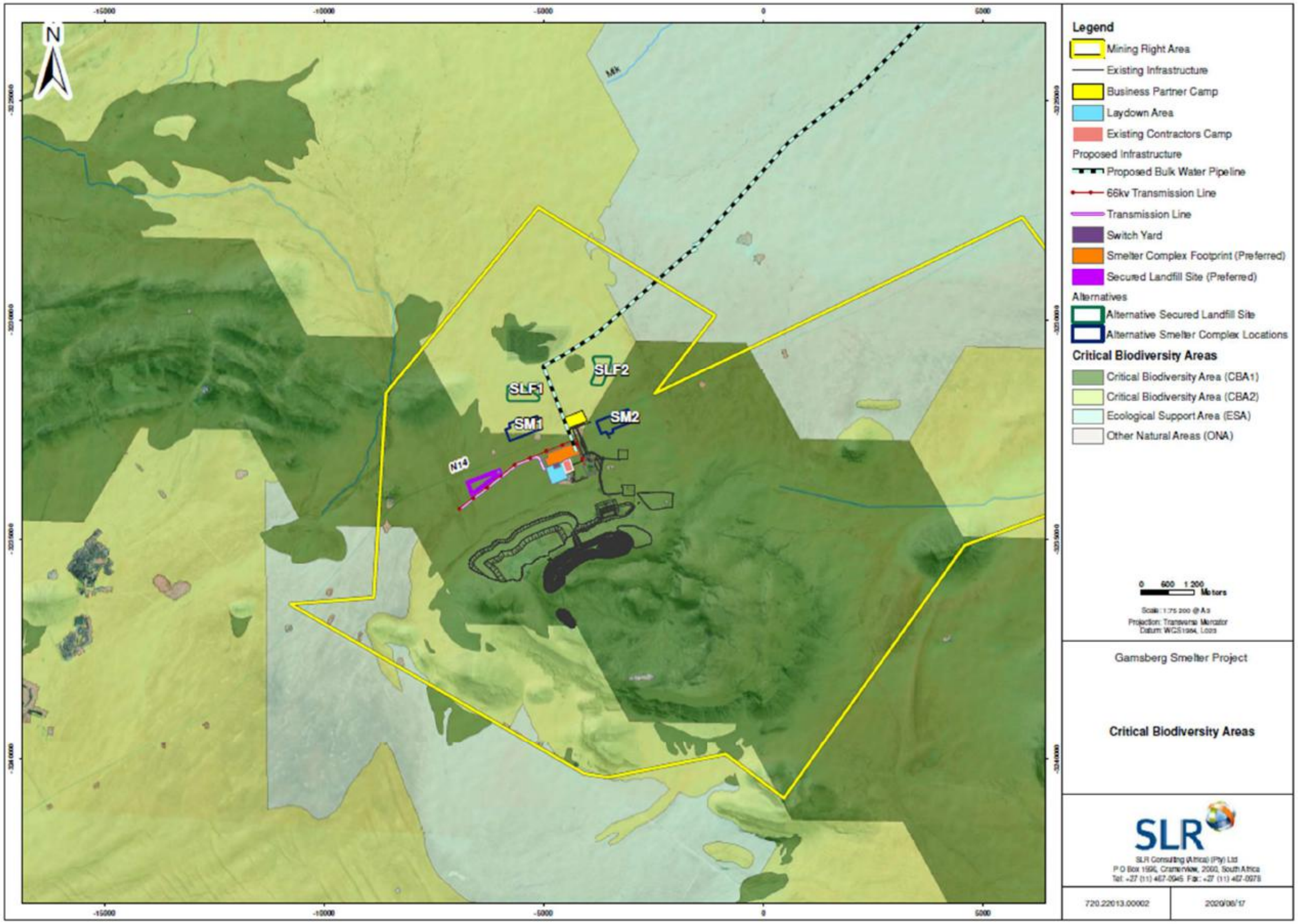


Figure 17. Critical Biodiversity Areas (CBA) (Holness & Oosthuysen 2016) map for the study area, showing that the majority of infrastructure lies within areas classified as CBA1.

CBA1 sites are considered 'irreplaceable' and are required for meeting biodiversity targets and there are no or few other options for meeting biodiversity targets for features associated with these areas. As such, development within such areas is likely to result in an irreplaceable loss of biodiversity, contrary to the NEMA principles. Development within CBA1 which may impact on the ecological features, processes or condition should be avoided. CBA2 units are also required to meet conservation targets for biodiversity features or ecological processes but offer more flexibility for development than CBA1 units.

The proposed Gamsberg Smelter Project development footprint and the existing Gamsberg Zinc Mine lies almost entirely within an area designated as a CBA1 while the area to the north of the N14 is designated as CBA2. The designation of the Gamsberg area as a CBA1 is largely based on the presence of localised habitat types and range-restricted flora. Within the CBA1 unit around Gamsberg there are specific habitat units, such as the calcrete gravel patches (described in Section 4.1.2), that are of higher conservation importance (and considered 'irreplaceable') than the adjacent extensive areas of flat sandy plains.

The Northern Cape CBA map makes use of 1600 ha hexagonal planning units. Each unit has a list of attributes such as the vegetation types that fall within it as well as other biodiversity pattern and process features. Even when a feature occupies a small proportion of the planning unit, the feature is associated with the whole unit. As such, development within a CBA may not affect all the features of the CBA and as such might not negatively impact the overall biodiversity pattern and process features the CBA was designed to protect. There are three planning units that fall within the footprint of the smelter and SLF. The features associated with each of them are listed below in Table 7. The results suggest that the area has been identified as an important area for biodiversity conservation in several conservation and protected area expansion plans. In addition, it is highlighted as an area with high climate resilience due to the topographic diversity of the area.

Table 7. Reasons underlying the CBAs within the three CBA planning units that fall within the affected area of the Smelter and SLF

Planning Unit Features	Feature Type	Planning Unit		
		North	East	South
Aggeneys Gravel Vygieveld	Vegetation Type		1	1
Bushmanland Arid Grassland	Vegetation Type	1	1	1
Bushmanland Inselberg Shrubland	Vegetation Type	1	1	1
Bushmanland Sandy Grassland	Vegetation Type			1
Bushmanland Core PA Development Zone	Conservation Plan	1	1	1
SKEP expert areas	Conservation Plan		1	1
Threatened species	Biodiversity Pattern		1	1
Namakwa CBA1	Conservation Plan	1	1	1
Namakwa CBA2	Conservation Plan	1	1	1
All Rivers	Ecological Process	1	1	
Large high value climate resilience areas	Ecological Process	1	1	1
NPAES Protected Area and Focus Areas	Conservation Plan	1	1	1
Landscape structural elements	Ecological Process	1	1	1

Of relevance to the proposed Gamsberg Smelter Project is that many of these features are predicted to be significantly affected or lost as a result of mining. The actual and expected biodiversity impacts of the Gamsberg Zinc Mine (which was authorised within what was later delineated as a CBA1) on irreplaceable and constrained habitats has required the mine to implement a biodiversity offset to compensate for its residual negative impacts (as described in Section 3.3). The impact of the proposed Gamsberg Smelter Project will be assessed in the context of the mine development and its additional impacts in Section 6. Given the presence of the existing Gamsberg Zinc Mine, the additional impact of the Smelter and SLF on the CBA value of the area is likely minimal. However, what remains important and what should not be discounted is the presence of habitats and plants of plant species of conservation concern in the area. Although the mine has had to implement a biodiversity offset, habitats such as the calcrete gravel patches are considered irreplaceable and not-offsettable as species of high conservation concern in these habitats are not well-represented elsewhere. The implication of this is that, despite the biodiversity offset, there remains valuable biodiversity within the site and mitigation needs to be taken to limit and reduce impacts on these features.

4.4 Habitat Modification

Habitats within the footprint of the proposed Gamsberg Smelter Project components are considered largely natural, affected mainly by historical grazing and more recently by dust from the adjacent mining operations on the Gamsberg Inselberg. It is possible that succulent plants in the wider area around Aggeneys may be targeted for illegal collection. Future threats to habitats are expected to occur in the wider area from the expansion of renewable energy projects which may have a significantly greater footprint of between 2000 and 6000 ha over time, considerably increasing the risk of cumulative negative impacts.

5 SITE SENSITIVITY ASSESSMENT & EVALUATION OF ALTERNATIVES

The sensitivity mapping of the study area builds upon the previous fine scale vegetation mapping by Desmet (2013), as amended by the results of the January 2020 survey, and the assignment of habitats as irreplaceable, constrained and flexible based on the Gamsberg Zinc Mine EIA (Botha *et al.* 2013) which provided a guide to informing the selection of alternatives for assessment. The location of alternatives in relation to irreplaceable, constrained and flexible areas is illustrated in Figure 18.

Although there are elements of similarity in the criteria used to define irreplaceable and constrained areas, and the criteria used to define ecological sensitivity, these are not the same concepts and ecological sensitivity of different parts of the site are classed as low, medium, high and very high, based on the definitions provided in Table 8.

5.1 Irreplaceable, Constrained and Flexible Classes

Irreplaceable areas are "globally rare features with extents of only a few thousand hectares or less. They are associated with species of conservation concern or keystone ecological processes. Spatial biodiversity planning for the SKEP project and Namakwa District Bioregional Plan have explicitly considered these features and set targets of 100% for these features implying that they are irreplaceable" (Desmet 2013). In the Gamsberg area, these irreplaceable features comprise: the kloof, headwater seep, springs and gravel patches (including the calcrete gravel patches), mapped as red areas in Figure 18. These areas do not have explicit national conservation targets as they are sub-vegetation types.

Constrained areas are features of lower conservation importance than irreplaceable areas but which are important for meeting conservation targets or for maintaining ecological processes. Constrained areas mapped include plains quartz or feldspar gravel; streams or washes.

All areas outside of the irreplaceable and constrained areas are referred to as 'Flexible' and comprise widespread habitat features of lower conservation importance. In the proposed Gamsberg Smelter Project area these include flat or hummocky sandy plains, and mobile sandy dunes.

All the alternatives for the proposed Gamsberg Smelter Project components were selected as they were sited in areas outside of irreplaceable or constrained areas and therefore considered 'flexible'. However, all sites are located within either CBA1 or CBA2 (see Figure 17); SM2 and SM3, and SLF2 and SLF3 are all within CBA1.

5.2 Ecological Sensitivity

The ecological sensitivity of the different units to development was rated based on a combination of criteria in Table 8 drawing upon relevant criteria contained in the draft Guidance for Species Protocols (SANBI, 2020). A summary ranking of the alternatives is contained in Table 21.

Table 8. Summary of Criteria Informing Ecological Sensitivity Classes

Sensitivity Class	Sensitivity Criteria
Very High	Critical habitats for range-restricted (Extent of Occurrence (EOO) <10 km^2) species of conservation concern listed on IUCN Red List of threatened species or South Africa's National Red List (CR, EN, VU or Nationally Rare); large (>100 ha) intact area for any conservation status of regional vegetation type or >5 ha for CR regional vegetation types; areas with high habitat connectivity serving as functional ecological corridors; unique ecosystems of very high importance for species of conservation concern and with limited signs of major past disturbance. These areas are considered completely irreplaceable with no options for offsetting loss, and typically have habitats that are unable to recover from major impacts or species unlikely to remain at a site or to return once the cause of disturbance is removed. These areas are unsuitable for development.
High	Habitats with confirmed populations for VU species or small areas (>0.01% and <0.1% of total vegetation type) of an EN vegetation type or large area (>0.1%) of a VU vegetation type); areas with range restricted fauna or high proportion (>10%) of range-restricted flora or presence of unique plant/fauna assemblages; or of high importance for ecological processes that sustain species of conservation concern; large (>20 ha but <100 ha) intact area for any conservation status of a regional vegetation type or > 10 ha for EN regional vegetation types; good habitat connectivity with functional ecological corridors an only minor current ecological impacts with no signs of major past disturbance. These areas are unlikely to be able to recover fully after a relatively long period (>15 years required to restore less than 50% of the original species composition and functionality of the receptor functionality), or with species that have a low likelihood of remaining at a site even when a disturbance or impact is removed. These areas are considered unsuitable for development due to a very likely impact on species or habitats of conservation concern and where mitigation is unlikely to reduce impacts to acceptable levels.
Medium	Areas with confirmed populations of NT species, rare plant species; any area of threatened vegetation type with status of VU; moderate to low numbers of range-restricted flora species; > 50% of Natural Habitat; Medium (>5 ha but <20 ha) semi-intact area for any conservation status of regional vegetation type or > 20 ha for VU regional vegetation types; areas with only narrow corridors of good habitat connectivity or larger areas of poor habitat connectivity and exhibiting mostly minor current ecological impacts with some major impacts (e.g. established population of alien and invasive flora) and a few signs of minor past disturbance; moderate rehabilitation potential; Areas that will recover slowly (more than 10 years to restore >70% of original species composition and receptor functionality or species with moderate likelihood of remaining at the site. May be suitable for development with additional mitigation beyond standard practice.
Low	Areas with no confirmed or highly likely populations of species of conservation concern or with no confirmed or highly likely populations of range-restricted species; <50% of Natural Habitat with limited potential to support species of conservation concern; Small (>1 ha but <5 ha) area with almost no habitat connectivity but migrations still possible across some transformed or degraded natural habitat. Low rehabilitation potential. Presence of several minor and major current ecological impacts; Habitat that can recover relatively quickly (~ 5-10 years) to restore >70% of the original species composition and functionality of the receptor functionality, or species that have a high likelihood of remaining at a site or returning once the disturbance or impact has been removed. These areas are most likely suitable for development with standard mitigation requirements.
Very Low	Areas with no confirmed and highly unlikely populations of species of conservation concern or with no confirmed and highly unlikely populations of range-restricted species and with no Natural Habitat remaining; Very small (<1 ha) areas with no habitat connectivity (except for flying species or flora with wind-dispersed seeds). May have several major current ecological impacts. These areas are most likely suitable for development with limited mitigation requirements.

The sensitivity mapping is presented in Figure 19.

The field survey in January 2020 included a walkover of each alternative site to verify the sensitivity of each site and to provide additional input into the alternatives assessment. During the survey, a new calcrete gravel patch was identified near the SLF alternative 3 which was not previously surveyed or mapped and which has influenced to an extent, the findings of the alternatives analysis included in the Scoping Report. In summary, it has identified that the SLF Site 2 overlaps with a large calcrete gravel patch of high biodiversity sensitivity, thereby confirming that this site would be unsuitable for development.

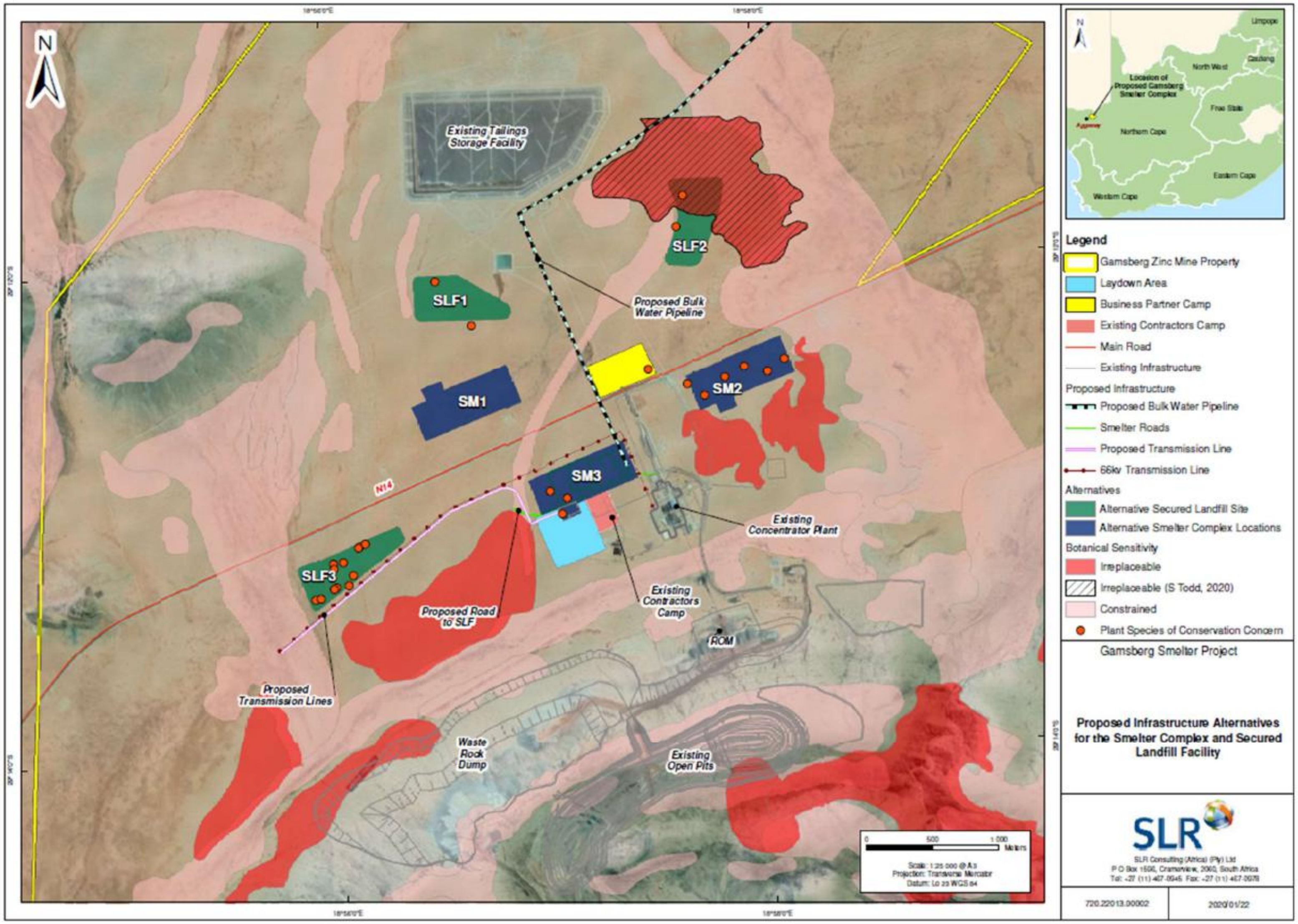


Figure 18. Location of alternatives in relation to irreplaceable and constrained areas, and including confirmed locations of protected, threatened and range-restricted plants
Note: the red areas near SM3 and SM2 are irreplaceable calcrete gravel patches defined by Desmet (2013) while the hatched red area is a large calcrete gravel patch defined by Todd in January 2020.

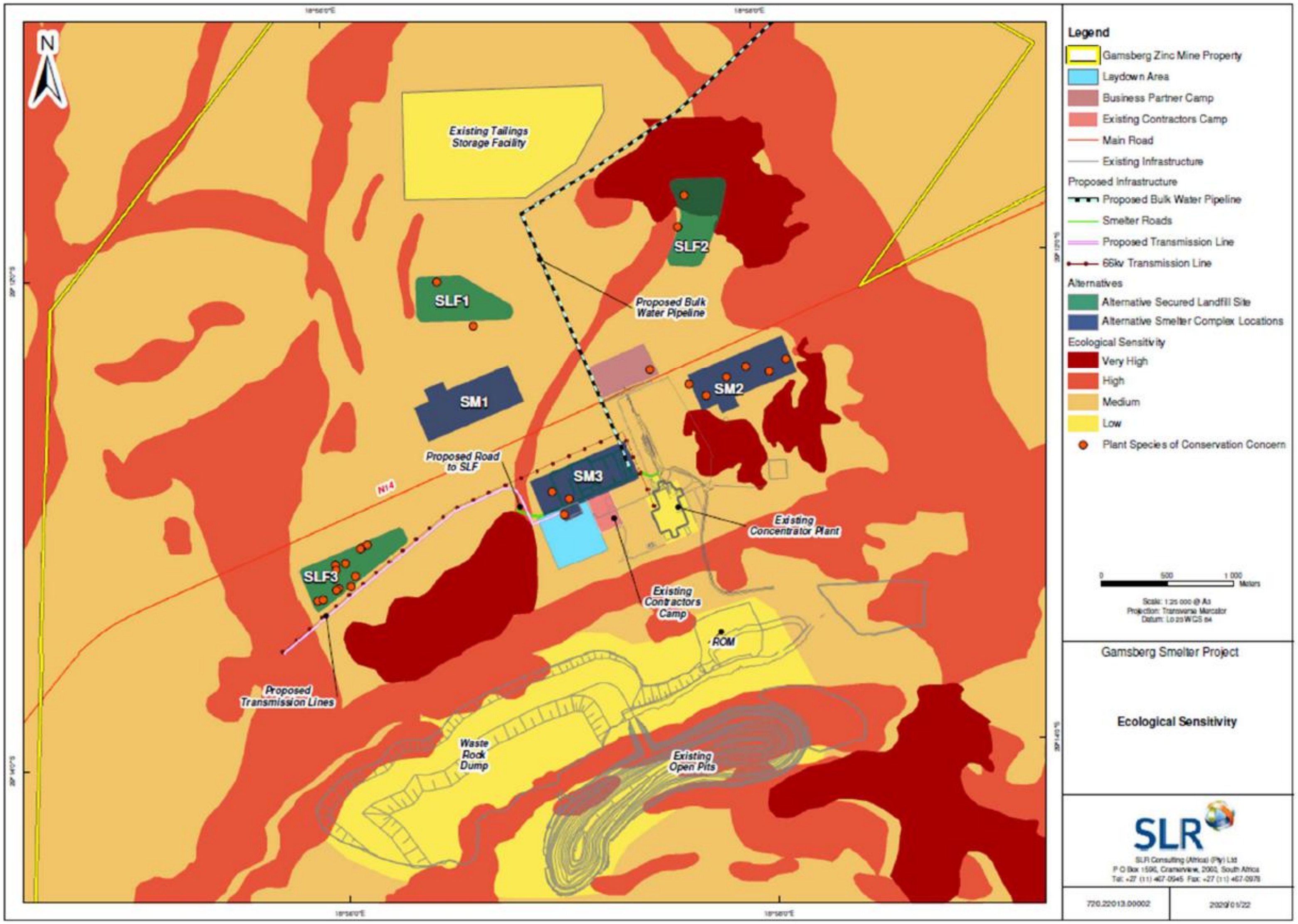


Figure 19. Location of alternatives in relation to ecological sensitivity, and including confirmed locations of protected, threatened and range-restricted plants Note: the red areas near SM3 and SM2 are irreplaceable calcrete gravel patches defined by Desmet (2013) while the hatched red area is a large calcrete gravel area defined by Todd in January 2020.

In summary, while recognising that all the sites are in a designated CBA1 or CBA2, the open plains of the proposed Gamsberg Smelter Project footprint are generally considered medium sensitivity relative to the adjacent calcrete gravel patches which are very high sensitivity. Within the typical flat sandy plains habitat the abundance of species of conservation concern is relatively low: some protected and Red-listed species such as *Hoodia gordonii* and *Aloidendron dichotomum* (VU) are present at a relatively low density. The various smelter and SLF alternatives are compared in Table 9 and illustrated in Figure 18 and Figure 20.

Table 9. Comparative assessment of the different Smelter and SLF Alternatives

Alternative	Ecological Preference	Habitat Type & CBA status	Sensitivity	Reasons (incl. potential issues)
SMELTER ALTERNATIVES (SM1-3)				
Smelter Alternative 1 (SM 1)	Rank 1	Bushmanland Arid Grassland: Flat Sandy Plains CBA2	Medium	SM1 is considered acceptable for ecological reasons as there are no species or habitats of concern within the footprint, even though the footprint of the development may increase slightly if placed here because of the need to construct additional services to this site. It is also within a CBA2 (while the other two options are in CBA1). Note: This option was not selected by Black Mountain Mining as it is located north of the N14 and was considered problematic for traffic safety reasons.
Smelter Alternative 2 (SM 2)	Rank 3	Bushmanland Arid Grassland: Flat Sandy Plains. CBA1	Medium	SM2 is in CBA1 and in close proximity and between two calcrete gravel patches that are considered irreplaceable and as a result, is not considered a desirable option for the smelter.
Smelter Alternative 3 (SM 3) (Selected)	Rank 2	Bushmanland Arid Grassland: Flat Sandy Plains CBA1	Medium	Although located within a CBA1 and close to a large calcrete gravel patch to the west, SM3 does not infringe on the calcrete gravel patch as may be expected for SM2. The site also has low abundance of plant species of conservation concern, with only a few *Euphorbia braunsii* individuals and would therefore be preferred over SM2.
SLF ALTERNATIVES (SLF1-3)				
SLF Alternative 1 (SLF 1)	Rank 1	Bushmanland Arid Grassland: Flat Sandy Plains CBA2	Medium	SLF1 is south of the existing mine tailings dam and represents an area of typical open plains with low abundance of plant species of conservation concern. SLF1 is the preferred landfill alternative from an ecological perspective and would have low impacts on fauna and flora. The reason it was not selected was similar to SM1 above.
SLF Alternative 2 (SLF 2)	Rank 3	Calcrete Patch (irreplaceable) CBA2	Very High	SLF2 is sited in an area of irreplaceable habitat with range-restricted and threatened plants in a newly identified calcrete gravel patch. It is therefore considered fatally-flawed.
SLF Alternative 3 (SLF 3) (Selected)	Rank 2	Bushmanland Arid Grassland: Flat Sandy Plains CBA1	Medium	SLF3 is located in CBA1, is located adjacent (to the north) to a large calcrete gravel patch; is on the edge of an ephemeral stream course or wash; is within a relatively ecologically productive area with deeper soils than the other alternatives (possibly due to its location at the edge of an ephemeral streamline or wash) and has a higher abundance of plant species of conservation concern than SLF2. From an ecological perspective this site is not ideal for the SLF. However, it is considered more acceptable than SLF2.

In summary, the sites selected for the smelter and SLF (SM3 and SLF3) are not the optimal sites based on ecological considerations. They were chosen primarily for technical, visual and safety reasons to optimise proximity to the mine’s concentrator plants and avoid traffic safety risks related to sites located north of the N14, on areas of lower sensitivity in a CBA2.

Both the preferred options for the Smelter and SLF are located in a CBA1 and although their direct footprint is located in areas mapped as medium sensitivity both facilities are in close proximity to irreplaceable calcrete gravel patches with several threatened plant species. SLF3 is also located adjacent to an ephemeral stream course and close to a 1:100-year floodline (SLR 2020b) and may require a flood protection berm. The impacts of the selected sites are assessed in Chapter 6.

Photo 1. SM1 area (view south). Typical and dominant species include *Salsola aphylla, Stipagrostis obtusa, S.ciliata, S.brevifolia, Aridaria serotina* and *Rhigozum trichotomum*. No significant biodiversity concerns.

Photo 2. SM2 area. Mostly sandy, with some exposed calcrete, but without any key endemic plant species of concern. Several *Aloidendron dichotomum* (VU) were located within the footprint. The primary concern is the proximity of SM2 to two large calcrete gravel patches with high conservation value.

Photo 3. SM3 view south. Preferred Smelter plant location as no major biodiversity concerns. The only species of conservation concern found was *Euphorbia braunsii*.

Photo 4. SLF1 area. Bushmanland Arid Grassland species *Salsola aphylla*, *Stipagrostis obtusa, S. ciliata, S. brevifolia, Aridaria serotina* and *Rhigozum trichotomum.* Considered a preferred site from biodiversity perspective.

Photo 5. SLF2. Open plains with exposed calcrete and quartz patches. Sensitive site with endemic calcrete specialists such as *Titanopsis hugo-sclecteri*. Least preferred for development.

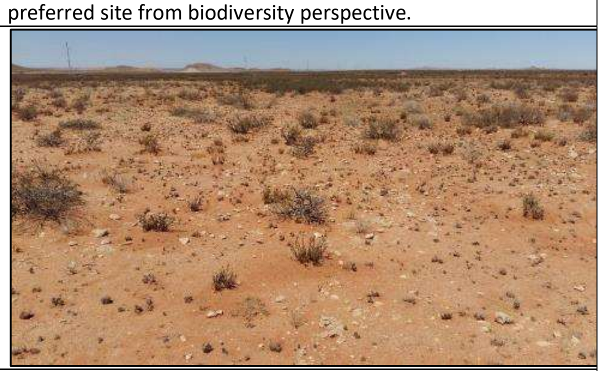


Photo 6. SLF3. No significant plant sensitivity although several notable species (*Hoodia gordonii, Euphorbia braunsii* and *Aloidendron dichotoma*) and with higher plant productivity in the west which would be attractive to fauna.

Figure 20. Photos representing the Smelter and SLF alternatives. SM3 and SLF3 were selected for the Gamsberg Smelter Project.

6 ASSESSMENT OF IMPACTS

In this section, the different impacts associated with the construction, operation and decommissioning phases of the preferred smelter and SLF locations are assessed, mitigation measures identified and pre- and post-mitigation impact significance ratings provided. The assessment of impacts takes into consideration the existing mining activities that are ongoing as certain mining impacts (e.g. noise and dust generation) are of higher magnitude than the proposed Gamsberg Smelter Project alone.

6.1 Construction Phase Impacts

During construction, the main activities that would generate impacts would be vegetation clearing and construction works and associated dust generation within the development footprint as well as some additional noise and disturbance for fauna within or nearby the development footprint. The impacts identified during construction are assessed below and include:

- Impact on vegetation and flora due to site clearance;
- Impact on sensitive calcrete gravel patches due to construction-related dust; and
- Impact on fauna due to construction phase noise and disturbance.

6.1.1 Impact on vegetation and flora due to site clearance

<u>Description of Impact</u>

Habitat loss resulting from the development is unavoidable and cannot be fully mitigated, but long-term loss of biodiversity has been minimised to some extent through the selection of alternatives and routing options that avoid areas of irreplaceable biodiversity (see Section 5). The extent of habitat loss during construction would be largely equivalent to the footprint of the development (i.e. about 90 ha), comprising Flat Sandy Plains vegetation, evaluated as Least Concern, and a widespread habitat type within the Bushmanland arid grassland area. Notable flora found in the proposed Gamsberg Smelter Project footprint comprise three Northern Cape protected species *Euphorbia braunsii, Hoodia gordonii* (Data Deficient)*, Aloidendron dichotomum* (Quiver Tree) (Vulnerable); several individuals of all three species were confirmed in the SLF location, while the proposed Gamsberg Smelter Plant footprint only had a few *E. braunsii*. Site clearance and associated use of earthmoving equipment and trucks may also encroach onto adjacent habitats which may pose a risk to irreplaceable calcrete gravel patches if not effectively restricted. In addition, construction staff may have additional impacts on sensitive habitats and flora if able to trample areas around the site or collect succulents or other plants. While loss of vegetation and flora are likely to be restricted to the local area within and immediately adjacent to the construction sites, the impact will be of high intensity and permanent duration.

<u>Mitigation</u>

As site clearance is a necessary and unavoidable requirement, there is little mitigation that can be applied to effectively mitigate the impacts on the vegetation within the footprint. Nonetheless, mitigation measures to reduce habitat disturbance and minimise impacts on flora are set out below.

- Undertake pre-construction surveys of the approved footprints (by a qualified botanist that is familiar with the area) to identify Red Listed and protected plant species and confirm search and rescue requirements, or other avoidance measures, where possible. Search and rescue of species of conservation concern should be conducted prior to clearing activities which shall include the above-mentioned species. The plant translocation programme should be aligned with ongoing search and rescue protocols developed for the Gamsberg Zinc Mine.
- Obtain permits for vegetation clearing and the translocation of protected species (listed in Table 5) from DENC prior to initiating site clearance. Removal of any protected trees within the footprint requires an additional permit from the Department of Environment, Forestry and Fisheries (DEFF) for which the lead time is about three months.
- Ensure any lay-down or other temporary infrastructure sites are located within low sensitivity areas.
- Minimise the development footprint as far as possible and rehabilitate construction-affected areas that are no longer required by the operational phase of the development.
- Fence the development area to avoid movement of construction vehicles into sensitive calcrete areas.
- Demarcate sensitive areas or individual trees in close proximity to the development footprint as no-go areas with construction tape, temporary fencing or signage and mark these on-site development plans for construction staff.
- Clearly mark vehicle routes and turning points and ensure all vehicle operators are made aware of restrictions on off-road driving in undesignated areas.
- Ensure construction workers are aware of prohibition on collecting succulent or other plants (e.g. through induction and toolbox talks) and are restricted from free movement outside of the demarcated construction sites.

<u>Impact Significance</u>

The impact of the proposed Gamsberg Smelter Project on vegetation and flora is assessed in Table 10.

Table 10. Impact on vegetation and listed plant species due to site clearance

Impact Phase: Construction							
Impact Description: Impact on vegetation and listed plant species due to site clearance							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**VL**	**VH**	**M**	**VH**	**Medium**	**Medium**	**High**
With Mitigation	**VL**	**VH**	**M**	**VH**	**Medium**	**Medium**	**High**
Can the impact be reversed?			No - modification of the 90 ha of habitat is necessary for the project and will persist for the project lifetime. Site clearance will result in residual habitat loss in the smelter and SLF footprints even after decommissioning and rehabilitation.				
Will impact cause irreplaceable loss of resources?			Yes, all vegetation within the footprint will be destroyed apart from any flora that can be gathered during search and rescue.				
Can impacts be avoided, managed or mitigated?			No, but through avoidance of sensitive areas, restricting clearance to smallest possible area for construction, search and rescue of some plants, and dust mitigation, the footprint and impact can be kept to a minimum. .				

Residual Impact	Loss of 90 ha of Flat Sandy Plains habitat of Least Concern and considered to be of medium sensitivity. The residual impact (post-mitigation) of land clearance is expected to be of medium significance.

6.1.2 Impact on vegetation and flora due to construction-related dust

Description of Impact

Site clearance of the 90 ha proposed Smelter Project footprint (assessed in Section 6.1.1) is likely to create windblown dust during and after vegetation clearance of the proposed Gamsberg Smelter Project footprint. In some cases, this could result in a plume of dust spreading across adjacent patches of irreplaceable calcrete gravel patches. These patches (described in Section 4.1.2) contain unique and range-restricted succulents many of which are only millimetres in size and are believed to be dependent on the white calcrete surface substrate. These are at risk of being smothered by increased dust and sand from the clearance of the Smelter Project footprint. The majority of the dust generated during construction will be from the sandy plains habitats of the footprint. Most deposition of dust around the Smelter Project sites during construction will be located close to the edges of the sites, probably within 100 m, and will decrease with increasing distance. The effects are likely to be relatively short term limited mainly to the construction phase as the dust is likely to be windblown over a wider area through natural wind events over a few months. Therefore, it is predicted that any residual effects of construction dust on adjacent calcrete patches will be localised and short term.

Mitigation

The key mitigation requirement is to minimise windblown dust from cleared footprints onto adjacent sensitive habitats. Mitigation measures are set out below.

- Implement dust suppression measures during construction and erect screening devices to minimise impacts of dust when clearing footprints near or adjacent to sensitive habitats and flora, such as calcrete gravel patches. This will be especially important at the selected laydown and smelter site.
- Clearly mark vehicle routes and turning points and ensure all vehicle operators are made aware of restrictions on off-road driving in undesignated areas.
- Fence off calcrete patches to prevent any vehicles access into this sensitive habitat.

Impact Significance

The impact of the proposed Gamsberg Smelter Project on vegetation and flora is assessed in Table 11.

Table 11. Impact on vegetation and flora due to construction-related dust

Impact Phase: Construction							
Impact Description: Impact on vegetation and flora due to construction-related dust							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**L**	**L**	**M**	**H**	**Medium**	**Medium**	**Medium**
With Mitigation	**L**	**L**	**L**	**M**	**Low**	**Low**	**Medium**
Can the impact be reversed?		Yes – the effect of construction dust on adjacent vegetation is likely to be of short duration and most dust is expected to dissipate naturally during windy conditions.					

Will impact cause irreplaceable loss of resources?	Unlikely - sensitive calcrete gravel patch habitats in adjacent sites (the closest of which is approximately 60 m to the west of the proposed laydown area) may be susceptible to spread of windblown dust during construction. However, windblown dust is a common feature of the arid flat landscape and it is uncertain the extent to which the calcrete patch may be affected.
Can impacts be avoided, managed or mitigated?	Mostly, through dust mitigation.
Residual Impact	Residual impacts (post-mitigation) of construction dust deposition on adjacent habitats will be of low intensity and likely to dissipate within a short period.

6.1.3 Impact on fauna due to site clearance

<u>Description of Impact</u>

During construction, the clearing of 90 ha of sandy plain habitats would cause permanent loss of faunal habitat for resident fauna such as snakes, lizards, rodents, and small mammals. Other construction impacts on fauna may result from increased mortality of some species through collision with construction vehicles or death from construction workers. While some uncommon, threatened or range-restricted fauna are confirmed to occur in the wider project area, none are resident and restricted to the footprint of the proposed Smelter Project.

Due to the proposed Gamsberg Smelter Project's proximity to the existing Gamsberg Zinc Mine activities, fauna activity presence in the proposed Gamsberg Smelter plant area is likely to be already reduced and restricted to more tolerant species. The proposed SLF site (SLF3) is located further away from the mine and faunal activity in this area is likely to be less influenced by current activities and possibly near-natural (at least for smaller fauna species). The clearance of faunal habitat while permanent will be of local extent and medium intensity.

<u>Mitigation</u>

As site clearance is a necessary and unavoidable requirement, there is little mitigation that can be applied to effectively mitigate the impacts on fauna within the footprint<u>. Specific mitigation to minimise impacts on fauna include:</u>

- Conduct search and rescue for any reptiles prior to site clearance. Particular attention should be paid to tortoises and clearing of bush clumps, stone/rubble piles and any other areas where reptiles are likely to be sheltering. Snakes to be removed by trained snake handlers and records maintained of snakes removed.
- Any fauna directly threatened by the construction activities should be removed to a safe location.
- All construction vehicles using internal roads should adhere to a low speed limit (40 km/h for cars and 30 km/h for trucks) to avoid collisions with susceptible species such as snakes and tortoises and rabbits or hares. Speed monitoring of construction vehicles and regular awareness raising of staff on this issue should be implemented.
- If any parts of the site are to be fenced, no electrified strands should be placed within 30 cm of the ground as some species such as tortoises are susceptible to electrocution as they do not move away when electrocuted but rather adopt defensive behaviour and are killed by repeated shocks.

Alternatively, the electrified strands should be placed on the inside of such fenced areas and not the outside.

- Ensure construction workers are aware of prohibitions on collecting fauna such as lizards, tortoises or snakes, and are restricted from free movement outside of the construction sites.

Impact Significance

The impact of site clearance on fauna is assessed in Table 12. The impact significance rating takes into consideration the likelihood that the existing mining activities are generating significant noise and dust and traffic disturbance in the area around the Smelter infrastructure.

Table 12. Impact on fauna due to site clearance

Impact Phase: Construction							
Impact Description: Impact on fauna due to site clearance.							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**L**	**VH**	**L**	**H**	**Medium**	**Medium**	**High**
With Mitigation	**L**	**VH**	**L**	**H**	**Medium**	**Medium**	**High**
Can the impact be reversed?			No. Site clearance will cause permanent loss of faunal habitat in the footprint.				
Will impact cause irreplaceable loss of resources?			Not likely as there do not appear to be any significant fauna populations of concern within the proposed footprint for the Gamsberg Smelter Project.				
Can impact be avoided, managed or mitigated?			Partly, by minimising the cleared footprint and search and rescue of fauna.				
Residual Impacts			Site clearance of 90 ha would have a long-term residual impact on faunal habitat of the flat sandy plains around Gamsberg. However, no threatened or range restricted species are predicted to be affected. .				

6.1.4 Impact on fauna due to construction phase noise and disturbance

Description of Impact

During construction, the noise and disturbance generated by clearing of vegetation and earthmoving equipment would cause localised displacement and disturbance for fauna such as snakes, lizards, rodents, and small mammals. However, due to the proposed Gamsberg Smelter Project's proximity to the existing Gamsberg Zinc Mine activities, fauna activity presence in the proposed Gamsberg Smelter plant area is likely to be already reduced and restricted to more tolerant species. Since the mine is operational day and night the Gamsberg area already experiences major noise levels from blasting and the operation of heavy haulage vehicles in the mine pit and on the top of the Gamsberg Plateau and when transporting ore down to the processing plant. The existing processing plant and crusher – located at a distance of approximately 500 m from the smelter - also generates significant noise.

The proposed SLF site (SLF3) is located further away from the mine and faunal activity in this area is likely to be less influenced by current activities and possibly near-natural (at least for smaller fauna species). Noise and disturbance impacts would be high during construction and then may decline to some degree during operation. Lighting impacts would start during construction and continue until closure of the mine/ smelter. Night lighting attracts insects which has a negative impact on their populations as there can be high mortality rates at lights, while the insect activity can also attract bats.

While some fauna become accustomed and habituated to noise, there are also some fauna which rely extensively on their hearing to find their prey or to avoid their predators. Such species are likely to move away from the mine or become eliminated from areas impacted by noise. Bat-eared foxes are a typical example of a species which relies heavily on sound for prey detection, while gerbils are typical species of arid areas which have enlarged auditory bullae for enhanced hearing for predator avoidance. Although these are not species of concern, impacts on these species can lead to ecosystem-wide impacts as they play important roles as predators and as agents of soil disturbance, both of which are important for general biodiversity maintenance.

Since fauna are not equally sensitive to disturbance, the extent of noise impacts on fauna is difficult to quantify objectively but for the purposes of this proposed Gamsberg Smelter Project assessment, it is assumed that noise and other construction related impacts on fauna would occur within a 200 m-300 m radius from the infrastructure and have short-term effects during construction. Much of this distance would overlap with the adjacent areas that are already experiencing increased disturbance from mine activities.

Mitigation

Little mitigation is feasible for construction noise and disturbance on fauna besides the mitigation measures listed under Section 6.1.3. In addition, the following mitigation is applicable:

- Lighting should be done with low-UV type lights (such as most LEDs) as far as practically possible, which do not attract insects and which should be directed downwards.

Impact Significance

The impact on fauna of construction noise and disturbance is assessed in Table 13. The impact significance rating takes into consideration the likelihood that the existing mining activities are generating significant noise and dust and traffic disturbance in the area around the Smelter Project infrastructure.

Table 13. Impact on fauna due to construction phase noise and disturbance

Impact Phase: Construction							
Impact Description: Impact on fauna due to construction-phase noise and disturbance.							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**L**	**L**	**L**	**H**	**Medium**	**Low**	**High**
With Mitigation	**L**	**L**	**L**	**H**	**Medium**	**Low**	**High**
Can the impact be reversed?			Yes, Construction disturbance on fauna will significantly reduce at the end of construction (although some noise will continue throughout operations).				
Will impact cause irreplaceable loss of resources?			Not likely as there do not appear to be any significant fauna populations of concern within the affected Smelter Project area.				
Can impact be avoided, managed or mitigated?			Only partly as noise, lighting and construction phase disturbance cannot be entirely avoided or mitigated.				

Residual Impacts	Noise and disturbance during construction cannot be mitigated, but would be short-term and no significant residual impact on fauna is predicted.

6.2 Operational Phase Impacts

The proposed Gamsberg Smelter operation and associated activities are expected to generate some additional dust over and above the existing dust generated from mining as well as other air emissions which are predicted to potentially negatively impact on vegetation and flora. The operation of the proposed Gamsberg Smelter would generate some additional noise from the smelter itself as well as the transport of waste material to the SLF.

Operational impacts of the proposed Gamsberg Smelter Project are assessed below for:

- Impact on vegetation due to dust deposition (fallout);
- Impact on vegetation due to changes in ambient air quality from gaseous emissions and heavy metal deposition (fallout);
- Impact on vegetation due to groundwater contamination; and
- Impact on fauna due to operational activities.

6.2.1 Impact on vegetation and flora due to dust deposition

<u>Description of Impact</u>

Dust is a particular issue associated with the existing Gamsberg Zinc Mine due to the nature of the specialised habitats and plant species associated with the area. The dwarf succulents associated with the quartz and calcrete gravel patches in proximity to the mine are edaphic specialists, with very specific and narrow habitat requirements. Both their small size and the specificity of their habitat requirements are likely to make them vulnerable to the dust from the mine.

Dust can have physical effects on plants, it can interfere with leaf function, decrease photosynthesis, increase transpiration and change plant moisture dynamics. Critical dust loads that result in significant alterations in sensitive plant functions vary with the particle size distribution and colour of the dust. Specific plant characteristics mediate dust impacts. Dust may exacerbate other effects (e.g. pH change).

From a summary review of air quality effects on vegetation (Appendix 7) it appears that smaller dust particles may have a greater impact than larger particles. This is of significance because smaller dust particles travel further from their source than larger particles, with the result that dust impacts do not necessarily decline in proportion to overall dust fallout rates, but may extend across the depositional area of the smaller dust particles. Dust can impact leaf physiology of plants through causing abrasion, blocking stomata, and affecting the plants ability to regulate water content of cells and to photosynthesise. Photosynthesis is further reduced through direct shading, while dust can also increase leaf temperatures, resulting in an overall decline in plant vitality. In a desert environment, where plants are physiologically challenged in terms of managing heat and water supply, these dust impacts could potentially have significant negative impacts on long-term survival and reproductive rates. Although it is difficult to speculate on the impact of dust on the dwarf succulents which characterise many of the important species of the Gamsberg and surrounding plains, it is possible that their thick cuticles and sunken stomata may make them more resistant to dust impacts than normal plants. However, the seedling stage may be more vulnerable to dust impacts as the young plants are often only a few millimetres in size across when freshly germinated and are vulnerable to heat, desiccation and physical damage from dust.

While increased deposition from the Smelter Project may change the temperature of the soil in areas close to the mine with potential negative impacts on dwarf succulents (which are already close to their temperature maxima.), this is likely to be limited as most dust generated by the project will be from the smelter stacks and expected to be light in colour. It is likely that some of the succulent species, such as *Lithops* or *Conophytum,* will suffer dust-related damage to their exposed leaf surfaces, which have specific transparent ‘windows’ which allow light into the interior of succulent leaves where the chloroplasts are located. Damage to these windows is likely to be a significant problem for these plants as they usually only replace their leaves once a year. Grasses and deciduous shrubs are likely to be more tolerant of dust than perennial species as they grow quickly after rains and drop their leaves at the end of the growing season so dust-induced water loss and temperature increases are less likely to be an issue than with species with longer-lived leaves. Shrubs with perennial leaves face a greater risk as their leaves are usually longer-lived and would be exposed to dust for longer periods. The implications of these findings are that there is likely to be a gradual shift over time towards species that are tolerant of dust. These are also likely to be species that are less favoured by herbivores with the result that this would ultimately generate a zone of dust impact around the mine, with associated changes and gradients in the vegetation and faunal communities.

Another factor that may influence the response of vegetation to dust is that the mine dust is a darker grey colour in contrast to the lighter quartz sand of the natural environment - some of which is likely to have settled in the area around the smelter infrastructure and is likely to be remobilised from vehicle entrainment. This could have adverse thermal consequences for plants situated on the plains, especially in the pale calcrete gravel patches. The dust is also likely to be nitrate enriched from blasting and over time could form an acidic solution when it comes in contact with water. However, although it cannot be ruled out, it is possible that the limited rainfall and natural windy conditions at times of the Gamsberg area may reduce the acidic influence on succulents.

As discussed in Section 3.3, the original Gamsberg Zinc Mine EIA considered dust impacts to be significant for sensitive habitats (quartz and calcrete gravel patches, Gamsberg kloof and south slopes) if the dust input from mining results in a 10% change in baseline dust deposition or 20 $mg/m^2/day$, and for all other habitats if the dust input from mining results in a 25% change in baseline dust deposition or 50 $mg/m^2/day$. The same thresholds for dust are used to compare the potential impacts of the proposed Gamsberg Smelter Project against the modelled Gamsberg Zinc Mine impacts as there is no new evidence that this should be adjusted otherwise. These thresholds (of 20 $mg/m^2/day$ and 50 $mg/m^2/day$) are considered conservative and precautionary and are believed sufficient to cater for the uncertainties in predicting dust impacts on the different plant types in the Project Area. Other studies have confirmed dust impacts at significantly higher levels than the proposed thresholds used in the current study; Sharifi *et al*. (1997) reported that dust of 10 g/m^2 reduced photosynthetically active radiation absorption by 20% in desert shrubs while Farmer (1993) found negative dust effects on vegetation at between 1 and 7 g/m^2. However, it is important to recognise that there is a high degree of uncertainty as to the long-term impact of dust, and long-term monitoring at the site should be used to address this uncertainty (see Section 7).

Comparison of modelled dust deposition for the Gamsberg Zinc Mine and for the mine with the proposed Gamsberg Smelter Project (Figure 21 and Figure 22) shows that the smelter would have a small contribution to dust fall-out relative to the mine. This is supported by the results in Figure 6 in Section 3.4.2. Results clearly show that the 20 mg/m^2/day modelled dust contour for the smelter operations (dark purple line in Figure 21) for all scenarios of dust mitigation falls well within and occupies a significantly smaller footprint than the same modelled dust output contour for the mine operation (lime green line on outer edge). This is the same line used for the existing mine offset calculations (see Figure 5) which suggests that, in theory, for the habitat units mapped by Desmet in 2013, no additional offset should be required for dust generated by the Smelter Project. However, the identification of a 'new' calcrete gravel patch of approximately 100 ha to the east of the tailings facility and within the 20 mg/m^2/day contour for mine (and smelter) dust deposition confirmed during the January 2020 survey may need to be factored into any revised offset calculations. Additional surveys of this calcrete gravel patch during more optimal survey periods (after rain) are recommended to confirm its conservation importance and presence of threatened plants.

The cumulative impact of modelled dust deposition from the Gamsberg Zinc Mine and Gamsberg Smelter Project in relation to the biodiversity offsets secured for the mine are discussed in Section 6.4.2.

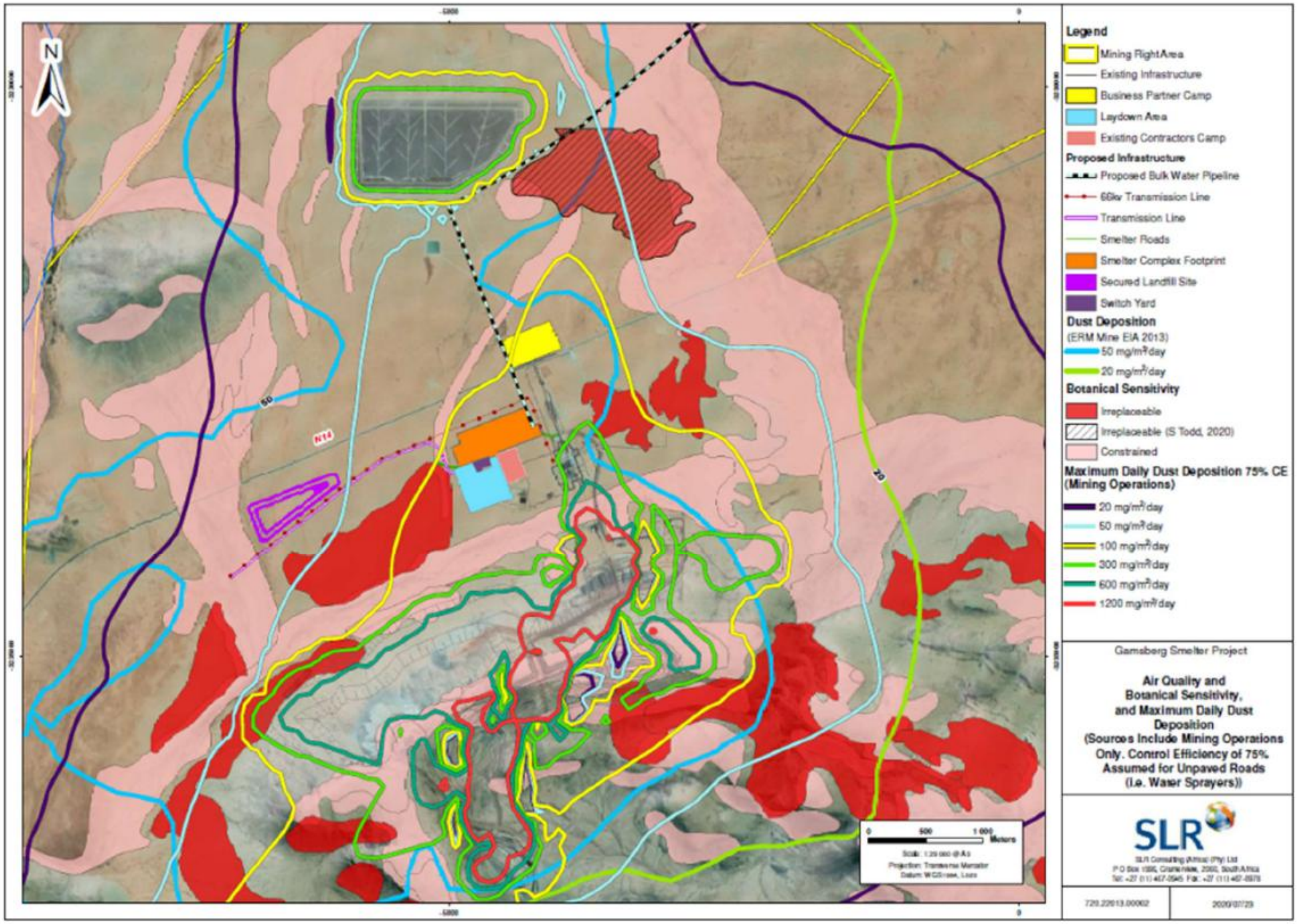


Figure 21. Extent of dust deposition (assuming 75% control efficiency) from the existing Gamsberg Zinc Mine only relative to previously modelled mine dust (outer light blue and green lines). Note: the 20 and 50 mg/m²/day deposition for the mine modelled by Airshed (2020) and for the EIA (2013) show a similar pattern but contours do not exactly coincide due to different model and meteorological parameters (see Section 3.4.2).

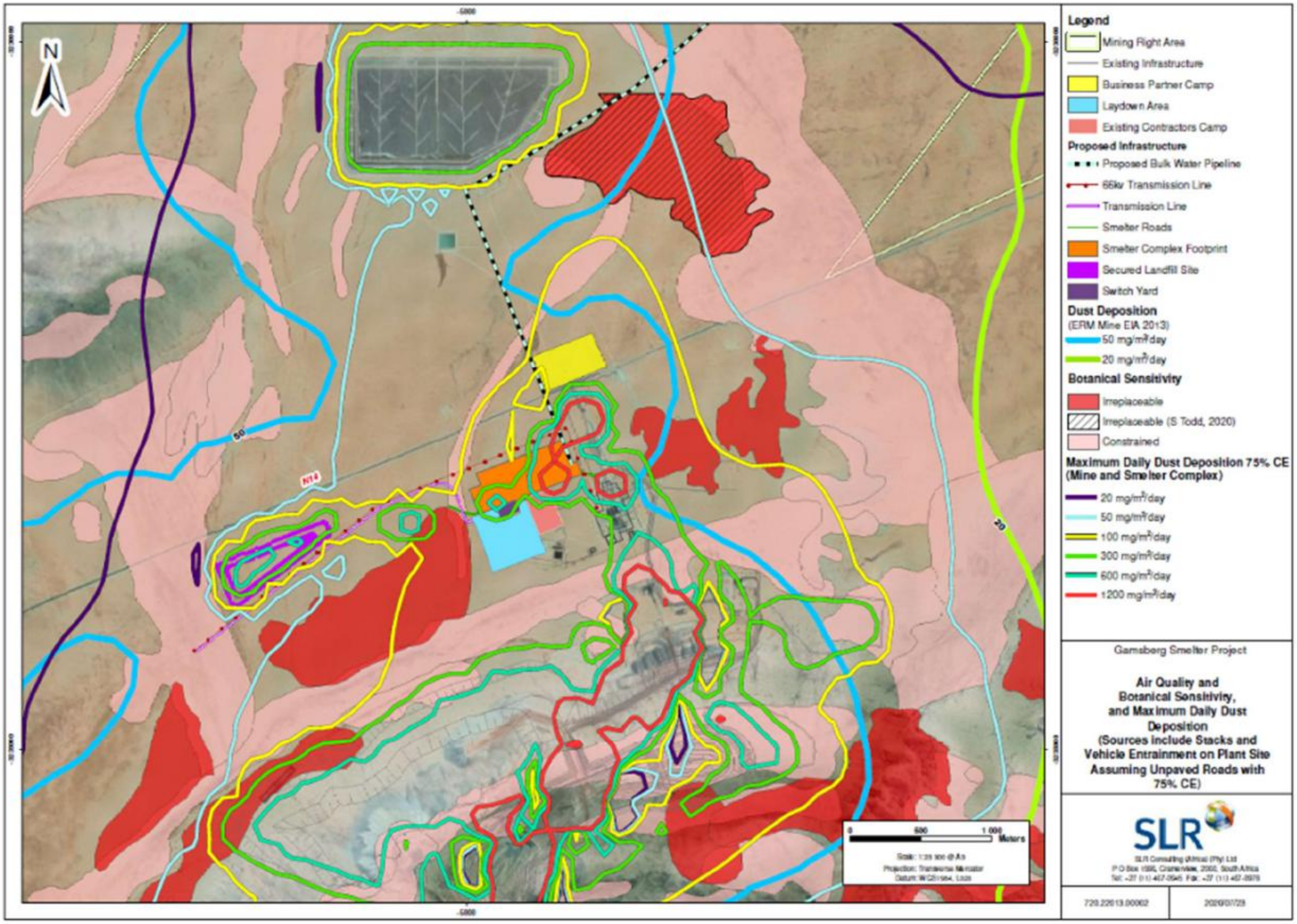


Figure 22. Extent of dust deposition (assuming 75% control efficiency) from the existing Gamsberg Zinc <u>Mine and proposed Gamsberg Smelter Project</u> relative to previously modelled mine dust (outer light blue and green lines). Note: this assumed mitigation of dust on unpaved roads which are now planned to be bitumen paved to minimise dust.

Mitigation

Note: The road between the proposed Gamsberg Smelter and SLF is planned to be paved with bitumen which will significantly reduce dust emissions from the transport of Jarofix to the SLF and this is taken into account in the pre-mitigation significance rating. The air quality modelling was done assuming an unpaved road and therefore the 75% CE model results are considered a reasonable basis for the impact assessment.

- Undertake regular daily or weekly checks of the proposed Gamsberg Smelter and SLF areas to record evidence of the extent of dust generation from unvegetated/bare areas to confirm the need for additional mitigation; and
- Cover, shield or protect all stockpiles or other sources that could generate dust from wind, where possible.

In addition to the above mitigation, dust bucket monitoring should be conducted at various sites around the smelter and SLF within the various modelled dust deposition zones to check the extent of dust fallout and congruence with the model's predictions. This dust bucket data should be correlated with vegetation monitoring data to determine long term dust impacts on sensitive vegetation.

Impact Significance

The impact of dust on vegetation and flora is assessed in Table 14.

Table 14. Impact on vegetation and flora due to dust deposition

Impact Phase: Operation							
Impact Description: Impact on vegetation and flora due to dust deposition							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**M**	**H**	**M**	**H**	**Medium**	**Medium**	**Medium**
With Mitigation	**M**	**H**	**L**	**H**	**Medium**	**Medium**	**Medium**
Can the impact be reversed?			Unlikely, once plant communities have experienced negative impacts due to dust, it is likely that even if the impact cause is ceased, that the species of concern are not likely to return to the specialised habitats they have been lost from.				
Will impact cause irreplaceable loss of resources?			Potentially, if there is significant impact on the calcrete gravel patches and other habitats of concern. However, the impact of mining is considered of significantly higher consequence relative to dust generated by the Smelter.				
Can impact be avoided, managed or mitigated?			Potential dust impacts generated from bare areas can be reduced to some extent through dust suppression and management. However, most dust mainly comprises $PM_{2.5}$ is generated from the stacks and cannot be mitigated.				
Residual Impact			There will be some habitat degradation that is an unavoidable impact of the development and cannot be fully mitigated (although the area predicted to be affected is within the area already calculated for the Gamsberg Zinc Mine offset).				

6.2.2 Impact on vegetation due to increased air emissions (SO_2, NO_2, lead (Pb) and zinc (Zn))

The air quality model evaluated the ground level concentrations of NO_2 and SO_2 and deposition of zinc and lead from the Smelter as these are likely to be emitted from the stacks. There may also be some fugitive contaminants from other metals such as cadmium, manganese, copper, mercury and arsenic in and immediately adjacent the Smelter through product handling (which have not been modelled), most of which will be contained in the by-products of the smelter which will be sold but which are not expected to be emitted through the stack. These could have potential impacts on vegetation immediately around the smelter (potentially within 50 m) but this is considered of low consequence due to the few plant SCC in the Smelter plant area.

The proposed Gamsberg Smelter Project would undoubtedly result in a decline in ambient air quality especially with regards to ground level NO_2 and SO_2 concentrations. The impacts of such air quality changes on vegetation are poorly known in arid systems. Although, the levels of NO_2 and SO_2 are considered low by human health standards, this says little about the potential response of the vegetation or particular plant species to these gasses. As the vegetation would be exposed on a continual and cumulative basis to these gasses, a long-term effect at levels below thresholds for human health is a possibility. The air quality plots (Figure 23 to Figure 26) indicate that increases likely to have noticeable impacts on vegetation would be restricted to a relatively small area in close proximity to the proposed Gamsberg Smelter but overlapping with the adjacent calcrete gravel patches. However, the impact zones for all the modelled emissions (Figure 23 to Figure 24) is predicted to be restricted to within the 20 mg/m^2/day modelled dust deposition area predicted to be impacted from the mine operations and which has technically been included in the calculation of the Gamsberg Zinc Mine biodiversity offset (see Section 3.3).

Sulphur Dioxide: Plants are sensitive to SO_2 and are affected by it both directly and indirectly; the direct effects may be acute or chronic, depending on the duration and intensity of the exposure. Sulphur dioxide inhibits photosynthesis by disrupting the photosynthetic mechanism. The opening of the stomata is promoted by sulphur dioxide, resulting in an excessive loss of water. Since SO_2 generally also acts to decrease plant performance, it may have a cumulative impact with dust fallout, and with other emissions such as NO_x. Although acid rain is not likely to be a significant issue at the mine, the ability of SO_2 to dissolve in mist is a potential problem because early morning fog is an occasional occurrence in the area and likely provides many small succulents with a significant additional moisture source. The possibility that this fog could become acidic as a result of SO_2 could impact on the local vegetation, even if this does not occur on a regular basis. Based on the predicted levels of SO_2 concentrations from the proposed Gamsberg Smelter at and below a conservative critical annual concentration of 10 $\mu g/m^3$(see

Table **4** in Section 3.4) the area of potential impact from SO_2 around the mine is predicted to be localised (Figure 23). Only at annual concentrations of SO_2 below 10 ug/m^3 does the air quality model predict there will be impacts on calcrete gravel patches. The area potentially affected by annual concentration of SO_2 at low concentrations of 1-2 ug/m^3 remains well within the residual impact area for which the existing Gamsberg Zinc Mine biodiversity offset has been calculated.

Nitrogen Dioxide: The increased NO_2 concentrations as a result of emissions from the smelter are likely to function in combination with SO_2 to increase acidification of the local environment. Similar to SO_2, the extent of this impact at conservative annual concentrations of 1, 2 and 2.5 ug/m^3 (i.e. well under the critical annual concentration value of 30 µg/m^3/ (CLRTAP 2017)) is however likely to be restricted to a relatively small area around the smelter plant, only affecting the calcrete gravel patches at annual concentrations of below 2 ug/m^3 (Figure 24). At all modelled NO_2 levels the impacts are expected to remain well within the area that has been used to calculate the Gamsberg Zinc Mine biodiversity offset. In the longer-term, it is possible that nitrogenous fallout from the blasting activities in the mine may stimulate plant growth following rainfall events, but it may also decrease drought tolerance, thereby making plant biomass more variable over time (Seymour *et al.* 2020). A question that remains to be seen is the response of different growth forms and especially dwarf succulents to increased nitrogen.

Zinc: Although zinc is generally well-tolerated by plants in natural environments, in strongly acidic soil, zinc phytotoxicity is the most extensive microelement phytotoxicity after natural phytotoxicity from aluminium or magnesium, and is far more important than Cu, Ni, Co, Cd, or other metals. No standard vegetation threshold or critical value for zinc exists and internet research on zinc toxicity on plants is difficult to confirm in relation to the vegetation of the proposed Gamsberg Smelter Project. In general, with decreasing soil pH, zinc solubility and uptake increase and potential for phytotoxicity increases. In acidic soils, zinc usually causes severe iron-deficiency chlorosis in dicots and grasses are usually much more zinc tolerant than dicots. However, in neutral or alkaline soils, grasses are more sensitive to soil zinc than are dicots, apparently due to the interference of zinc in phytosiderophore function. The soils of the Gamsberg area are generally neutral to fairly alkaline and given the underlying high zinc content (hence the presence of the zinc mine), zinc phytotoxicity is considered unlikely. It is possible, however, that zinc phytotoxicity could occur in areas with highest zinc fallout rates and possibly where high SO_2 and NO_2 ground level concentrations may result in soil acidification under moist conditions. Modelled deposition for zinc at 5 mg/m^2/day (Figure 25) extends over the eastern portion of the calcrete patch to the west of the smelter while much lower levels of 0.5 mg/m^2/day of zinc deposition extends across a larger area (although remains well within the modelled 50 mg/m^2/day dust deposition zone used to calculate the existing Gamsberg Zinc Mine biodiversity offset.

Lead (Pb): Lead exerts adverse effect on morphology, growth and photosynthetic processes of plants. High levels of lead also cause inhibition of enzyme activities, water imbalance, alterations in membrane permeability and disturbance of mineral nutrition (Sharma and Dubey, 2005). Despite its' apparent toxicity for plants and animals, critical thresholds of lead for vegetation in semi-natural environments have not been well-studied and there do not appear to be any accepted thresholds that can be applied to the current situation. Overall, there appears to be little consistency with regards to lead, zinc or other heavy metals and their thresholds with regards to significant negative impacts on natural ecosystems.

Soils with a higher pH (neutral to alkaline) appear to be significantly better at buffering vegetation from negative impact than acid soils. Regarding general heavy metal thresholds, Påhlsson (1989) contends that "*With our present knowledge it is difficult to propose a limit for toxic concentrations of Zn, Cu, Cd and Pb in soils*". Critical thresholds appear to be largely case and site specific due to the reasons mentioned above. Lead deposition of 5 mg/m^2/day has a similar modelled deposition zone to zinc (Figure 26), and may impact the calcrete gravel patch to the west of the smelter. At much lower levels of 0.5 mg/m^2/day of lead the modelled deposition zone extends north and west overlapping with calcrete gravel patches but (as with the other emissions), remains within the area calculated for the existing Gamsberg Zinc Mine Biodiversity Offset.

In summary, although zinc is an essential micronutrient for plants, it can cause toxicity in plants, especially where the soil pH is low. Lead on the other hand has no known purpose in plants and is not well tolerated by plants. In general, toxic effects in plants occur at lead concentrations about an order or magnitude lower than those required to generate zinc impacts. The levels of lead predicted to be emitted by the plant are low, but it is not clear how these would accumulate in the environment and while a short-term negative impact seems unlikely, there may be some long-term negative impacts of lead on the vegetation of the area close to the proposed Gamsberg Smelter. As the negative impacts of both of these metals are mediated by soil pH, the acidification of the soil near the proposed Gamsberg Smelter may increase the susceptibility of the vegetation to negative impact from these metals in the long-term. However, given the low levels of SO_2 and NO_x predicted to be generated by the proposed Gamsberg Smelter, the rapid acidification of the soil near the plant is considered unlikely. Furthermore, the abundance of calcrete in the affected area may provide a buffering and ameliorating role for vegetation as the soil is alkaline in these areas, with the result that acidification of the soil would likely require large amounts of acidic fallout before a significant change in pH occurred. However, these predictions have a low degree of confidence as they are based on best possible deductions and inferences about the potential responses of arid zone flora to increased emissions and the interplay of soil and climatic factors. A precautionary approach is required which ensures optimal avoidance and mitigation measures are implemented, and the implementation of a targeted and comprehensive monitoring programme to verify the basis for any vegetation changes over time.

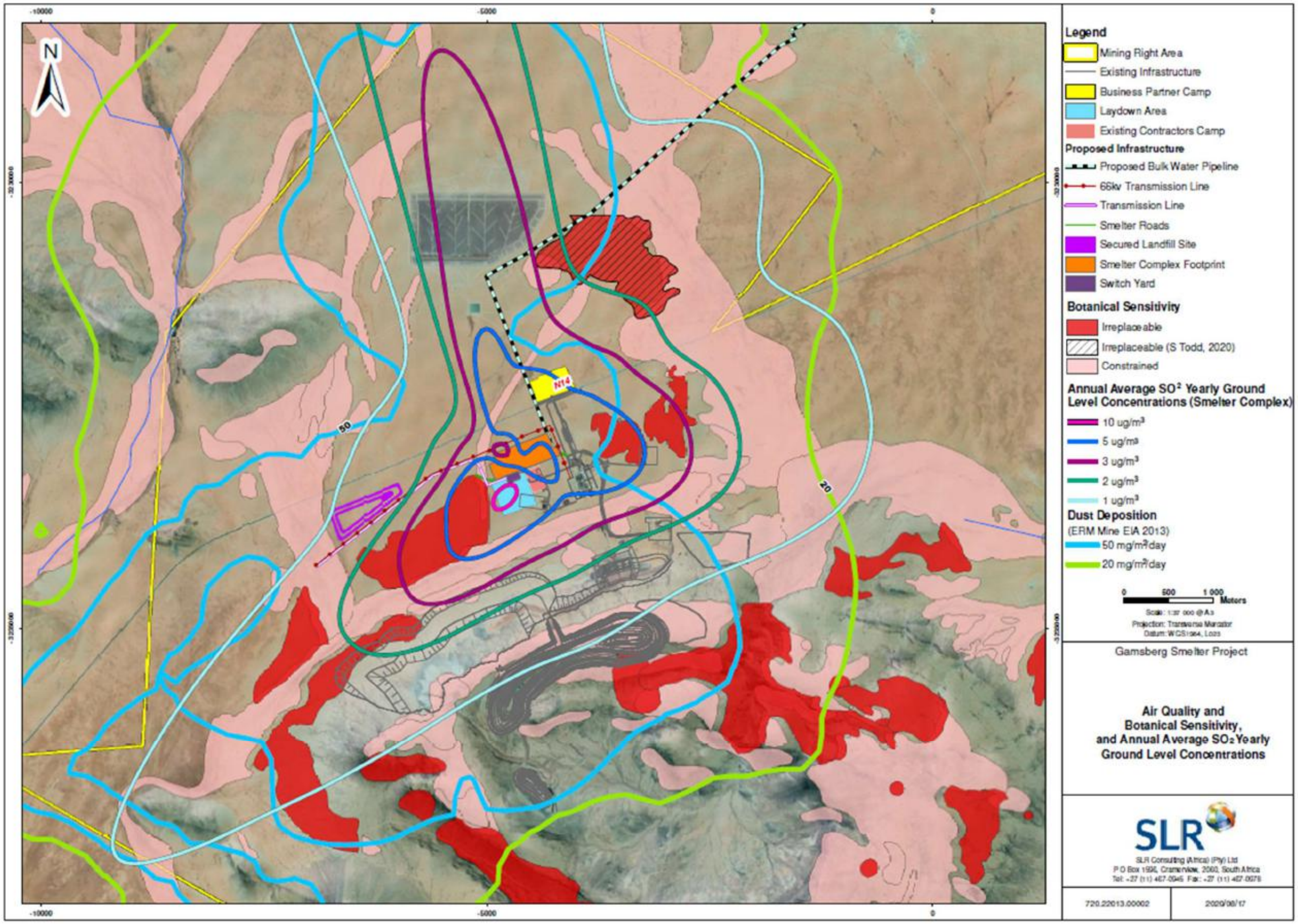


Figure 23. Modelled SO_2 annual ground level concentrations of 1, 2, 3, 5 ug/m^3 and 10 ug/m^3 relative to previously modelled mine dust contours used to determine the Gamsberg Zinc Mine biodiversity offset (outer light blue and green lines). Note: the lower limit of critical values of SO_2 for vegetation is 10 ug/m^3/year for lichens (CLRTAP 2017)

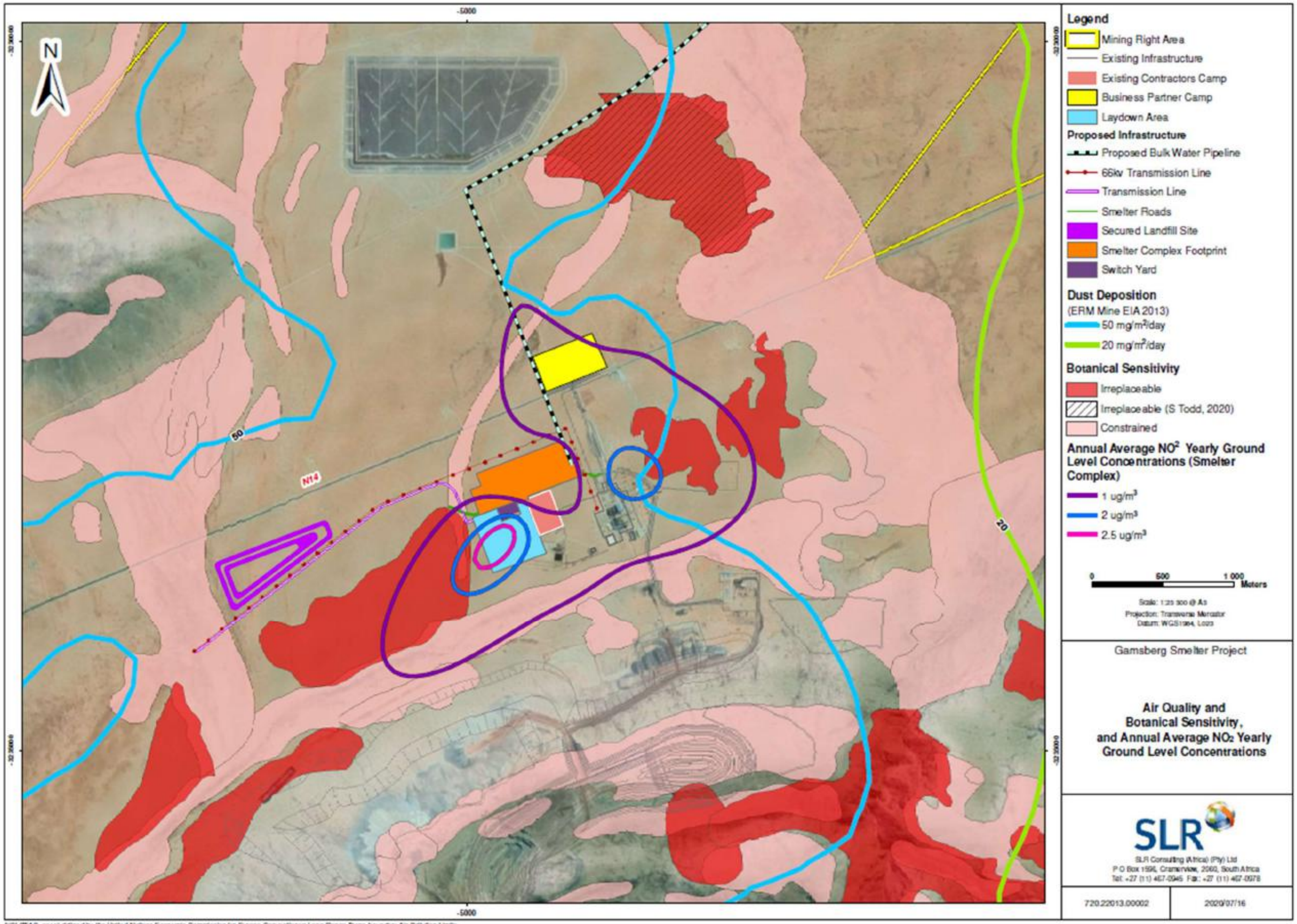


Figure 24. Modelled NO_2 annual ground Level concentrations of 1, 2 and 2.5 ug/m³ relative to previously modelled mine dust contours used to determine Gamsberg Zinc Mine biodiversity offset (outer light blue and green lines)

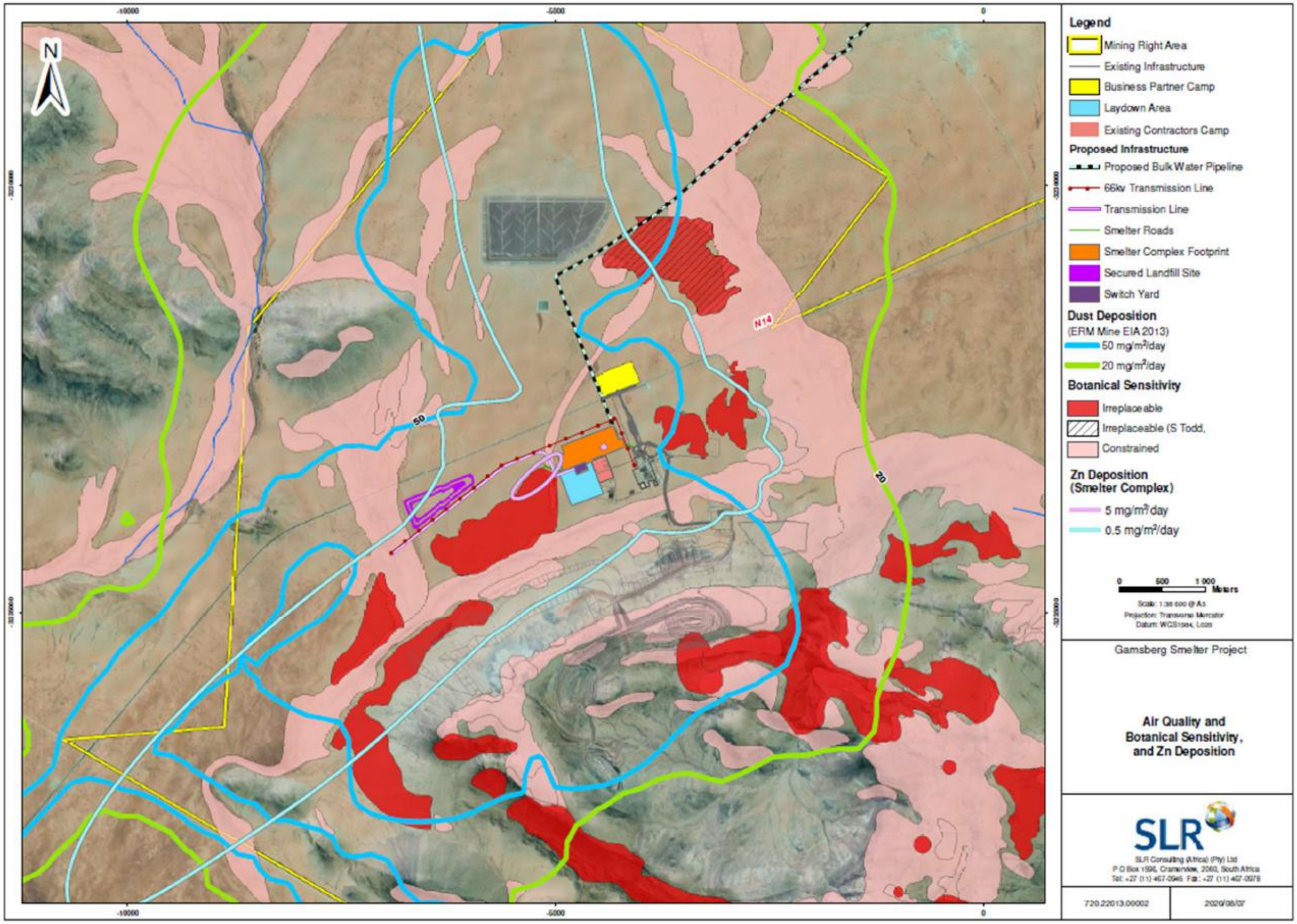


Figure 25. Modelled zinc deposition levels relative to previously modelled mine dust contours used to determine Gamsberg Zinc Mine biodiversity offset (outer light blue and green lines)

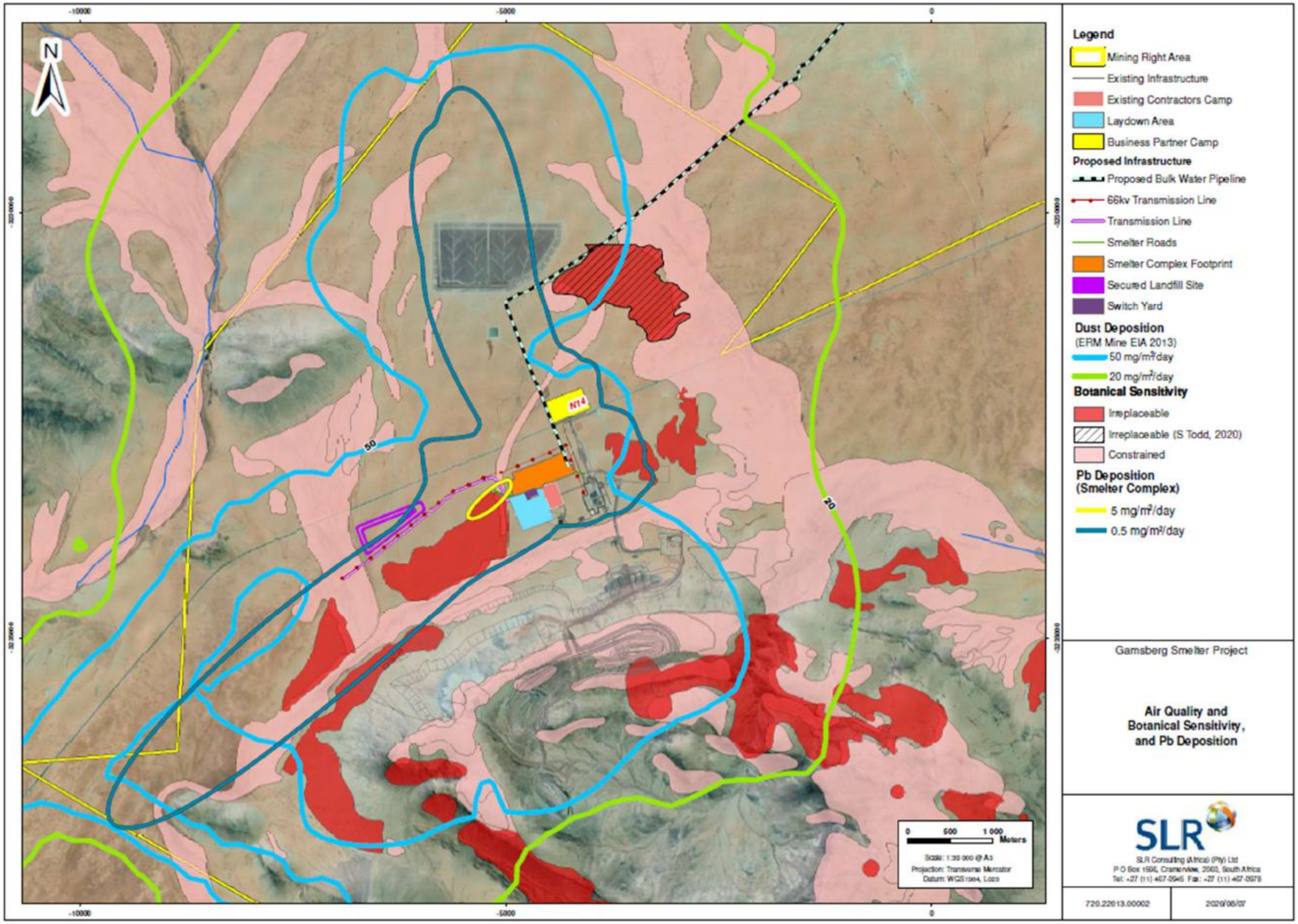


Figure 26. Modelled lead deposition levels relative to previously modelled mine dust contours used to determine Gamsberg Zinc Mine offset (outer light blue and green lines

Mitigation

Limited mitigation will be possible once the smelter is operational unless new process measures or new air emission reduction technology becomes available and is fitted. Therefore, the impact significance remains the same for the pre-mitigation and residual impact.

A comprehensive monitoring plan must be implemented to verify the project-related impacts relative to natural background variability linked to rainfall or climate change (see Section 7). If impacts due to the proposed Gamsberg Smelter Project become apparent over time, the project shall be required to investigate additional options that may be available over time to ensure the plant remains equipped with best available technology for air quality control to further mitigate air pollution impacts.

Impact Significance

The impact of air emissions on vegetation is assessed in Table 15.

Table 15. Impact on vegetation due to increased air emissions

Impact Phase: Operation							
Impact Description: Impact on vegetation due to increased air emissions (SO_2, NO_2, lead (Pb) and zinc (Zn))							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**M**	**VH**	**M**	**M**	**Medium**	**Medium**	**Low**
With Mitigation	**M**	**VH**	**M**	**M**	**Medium**	**Medium**	**Low**
Can the impact be reversed?			Any changes to irreplaceable succulent vegetation as a result of altered air quality is likely to persist for years especially due to potential for soil contamination. It is likely that grasses and other annuals would increase or restore more quickly after smelter decommissioning.				
Will impact cause irreplaceable loss of resources?			Possibly, if there is significant impact on the plants within calcrete gravel patches and other habitats of concern.				
Can impact be avoided, managed or mitigated?			It is assumed that international best practice design of air emission control will be implemented but emissions are likely to have some degree of impact on vegetation although this is assessed with low confidence.				
Residual Impact			As there will be pollutants emitted from the smelter, some residual impact is highly likely to occur on vegetation around the proposed Gamsberg Smelter complex, although is modelled to remain within the dust impact zone of the mine that has been quantified for the mine offset.				

6.2.3 Impact on vegetation due to groundwater contamination

The SLF will be lined with a Type 1 liner under the SLF and along its sides to prevent contamination and leachate entering the groundwater or soil horizons. The seepage captured by this liner will be captured and returned to the effluent treatment plant for re-use in the smelter complex. The SLF is located adjacent to a 1:100-year flood stream course and protection measures have been proposed in the surface water study to protect the western margin or to move it 150 m to the east. It also proposes the need for lined stormwater drainage channels to convey runoff into a 5000-ha stormwater dam on its southwestern corner. It is expected that the design of this SLF will be constructed in accordance with international good practice and that routine monitoring of groundwater will be implemented at new monitoring wells proposed on either side of the SLF.

Groundwater modelling undertaken for the proposed Gamsberg Smelter Project (as described in Section 3.5) predicts minimal change in groundwater quantity but does predict a potential for some leachates (such as sulphates, sodium, arsenic and lead) from the SLF to contaminate groundwater at depths of approximately 30 m below ground level. While the contaminated groundwater plume is predicted to spread over time, results suggest it is not predicted to impact on the Gamsberg kloof due to the presence of a groundwater barrier.

The majority of grasses and shrubs in the affected area have rooting depths that do not exceed 2 m and the only species with roots that are known to reach the required depths is *Boscia albitrunca* which does not occur in the area around the SLF and *Boscia foetida* subsp. *foetida* which does occur in the vicinity of the SLF. While it is possible the groundwater aquifer below the calcrete gravel patch to the south of the SLF may become contaminated over the lifespan of the proposed Gamsberg Smelter Project and beyond, the irreplaceable flora in this area is shallow-rooted and not predicted to be affected from groundwater contamination.

<u>Mitigation</u>

Mitigation should adhere to any measures proposed by the geohydrologists or hydrologists to minimise risk of groundwater or surface water or soil contamination. However, since it is assumed that the design will adhere to best international practice for liner systems to prevent and capture leachate, no additional mitigation is expected to reduce the residual impact significance.

<u>Impact Significance</u>

The impact of groundwater contamination on vegetation is assessed in Table 16.

Table 16. Impact on vegetation due to groundwater contamination

<table>
<tr><td colspan="8">Impact Phase: Operation</td></tr>
<tr><td colspan="8">Impact Description: Impact on vegetation due to groundwater contamination</td></tr>
<tr><th></th><th>Extent</th><th>Duration</th><th>Intensity</th><th>Probability</th><th>Consequence</th><th>Significance</th><th>Confidence</th></tr>
<tr><td>Without Mitigation</td><td>M</td><td>VH</td><td>L</td><td>L</td><td>Medium</td><td>Low</td><td>Low</td></tr>
<tr><td>With Mitigation</td><td>M</td><td>VH</td><td>L</td><td>L</td><td>Medium</td><td>Low</td><td>Low</td></tr>
<tr><td colspan="3">Can the impact be reversed?</td><td colspan="5">Should this impact occur it would be difficult to reverse as the groundwater pollution would persist for a long time.</td></tr>
<tr><td colspan="3">Will impact cause irreplaceable loss of resources?</td><td colspan="5">Unlikely as there is little vegetation in the area that utilises groundwater.</td></tr>
<tr><td colspan="3">Can impact be avoided, managed or mitigated?</td><td colspan="5">Design will include a Type 1 liner system to minimise risk of groundwater pollution If groundwater leachate occurs, this would be difficult to mitigate further.</td></tr>
<tr><td colspan="3">Residual Impact</td><td colspan="5">Based on information available to the specialist, the residual impact of groundwater contamination on vegetation is unlikely and evaluated as low significance.</td></tr>
</table>

6.2.4 Faunal impacts due to operational activities: dust, noise, and traffic

<u>Description of Impact</u>

The operation of the proposed Gamsberg Smelter Project will result in impacts on fauna through increased noise, lighting, dust, and human and vehicle disturbance, and loss of habitat. Increased dust deposition may make the vegetation less palatable for herbivores while noise disturbance is likely to displace resident animals and deter others from the area. Increased traffic moving between the proposed Gamsberg Smelter and SLF on a daily basis is likely to result in some mortality of lizards, snakes, tortoises, or rodents when crossing the road. However, since these impacts are already occurring as a result of the ongoing mining activities the proposed Gamsberg Smelter Project would cause minor intensification of these impacts in the localised operational area around the smelter footprints. It is expected these impacts would be limited to a radius of 200-300 m from the Smelter Complex infrastructure.

<u>Mitigation</u>

- Any fauna such as snakes, lizards or small mammals that is trapped or otherwise threatened by Smelter operational activities should be caught and removed to a safe location by trained snake handlers who should be available on site at all times.
- Where possible, night lighting should be done using downward-directed low-UV type lights (such as most LEDs) to minimise attracting insects, bats and nocturnal birds.
- All vehicles operating within the proposed Gamsberg Smelter Project area should adhere to a low speed limit (40 km/h max cars and 30 km/h trucks) to avoid collisions with susceptible species such as snakes and tortoises. Speed monitoring of vehicle and regular awareness raising of staff on this issue should be implemented.

<u>Impact Significance</u>

The impact of operational activities on fauna is assessed in Table 17.

Table 17. Impacts on fauna due to operational activities

Impact Phase: Operation							
Impact Description: Faunal impacts due to operational activities: dust, noise, and traffic.							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**L**	**H**	**M**	**H**	**Medium**	**Medium**	**High**
With Mitigation	**L**	**H**	**M**	**M**	**Medium**	**Low**	**High**
Can the impact be reversed?			Operational impacts on fauna will persist for the life of existing Gamsberg Zinc Mine and proposed Gamsberg Smelter Project. The footprint of the SLF will likely persist in perpetuity and is unlikely to return to provide faunal habitat.				
Will impact cause irreplaceable loss or resources?			Unlikely as there do not appear to be any significant populations of species of conservation concern within the affected area.				
Can impact be avoided, managed or mitigated?			Partly, though regulating staff and vehicles, but majority of impact on fauna will persist from mining and Smelter Project activities which will operate day and night.				
Residual Impacts			Faunal disturbance and habitat degradation in the vicinity of the proposed Smelter Project will last for the life of the smelter operation.				

6.3 Decommissioning Phase Impacts

6.3.1 Ecological impacts during decommissioning phase

Description of Impacts

Decommissioning of the proposed Gamsberg Smelter would involving dismantling of infrastructure and some degree of reclamation in accordance with an agreed land use vision. The SLF is likely to remain in place although it is possible that some Jarofix may be reusable for road construction material. Removal of the hard infrastructure would leave extensive areas of exposed substrate that would be vulnerable to invasion by weedy species and soil and wind erosion. It is however unlikely that any of the proposed Gamsberg Smelter Project footprints will be rehabilitated to a condition that they can support any species of conservation concern. Depending on the level of restoration, it may be possible to restore much of the footprint to a vegetated state that can support some natural fauna.

Mitigation

- A closure and decommissioning plan with detailed restoration plan and costing should be compiled for the mine and smelter with a goal of restoring the affected land back to a condition to be agreed with relevant authorities and stakeholders.
- All hard infrastructure should be removed from the site and recycled or disposed of in the appropriate manner.
- Any potentially dangerous fauna such as snakes or fauna threatened by the decommissioning activities should be removed by appropriately trained persons to a safe location (such as secured offset properties in the Gamsberg Nature Reserve) prior to the commencement of decommissioning activities.
- All hazardous materials such as fuel, oil, etc. should be stored in the appropriate manner to prevent contamination of the site. Any accidental chemical, fuel and oil spills or contaminated soils should be cleaned up in the appropriate manner and disposed of as hazardous waste.
- All vehicles accessing the site should adhere to a low speed limit (30 km/h for heavy vehicles and 40 km/h for light vehicles) to avoid collisions with susceptible species such as snakes and tortoises.
- No excavated holes or trenches should be left open for extended periods as fauna may fall in become trapped.
- Rip or scarify hardened soils and reseed or revegetate bare areas to allow regrowth and colonisation of a near natural ground cover of indigenous plants. Monitoring will be required to control alien invasive species. Decompaction and other earthworks to mitigate further dust generating impacts.
- All cleared and disturbed areas remaining after decommissioning should be rehabilitated with locally occurring species. Due to the arid nature of the area, active rehabilitation may be impractical in some areas and more passive approaches such as using seed traps and increasing surface roughness may yield acceptable results.
- An alien vegetation and erosion management monitoring and management programme should be put in place for at least three years after decommissioning. Any alien vegetation or erosion

problems observed should be rectified as soon as possible using the appropriate revegetation and erosion control works.

Impact Significance

The impact of decommissioning on ecological degradation from erosion and alien invasion is assessed in Table 18.

Table 18. Impact of decommissioning on ecological status

Impact Phase: Operation							
Impact Description: Ecological degradation from erosion and alien invasion in decommissioning phase.							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**L**	**L**	**M**	**H**	**Medium**	**Medium**	**High**
With Mitigation	**L**	**L**	**M**	**M**	**Medium**	**Low**	**High**
Can the impact be reversed?			Decommissioning-phase disturbance will be transient, and in the long-term would restore some functionality to the affected site.				
Will impact cause irreplaceable loss of resources?			No, decommissioning would not result in a loss of irreplaceable resources provided that the site is effectively rehabilitated.				
Can impact be avoided, managed or mitigated?			Although decommissioning would result in some disturbance, it would result in the restoration of the site to a near-natural state.				
Residual Impacts			It would not be possible to fully recover the diversity, composition and productivity of the affected areas to their previous state.				

6.4 Cumulative Impacts

The proposed Gamsberg Smelter Project and associated infrastructure would add to the overall footprint of the existing Gamsberg Zinc Mine. The footprint comprises the direct footprint where there has been habitat loss and transformation of intact vegetation to infrastructure and the mine void as well as the indirect footprint where noise, dust and other forms of disturbance extend some distance from the actual footprint area. The following cumulative impacts have been identified as likely to be associated with the construction and operation of the proposed Gamsberg Smelter Project:

6.4.1 Contribution of the proposed Gamsberg Smelter Project to Cumulative Impacts on CBAs and Sensitive Habitats

Description of Impacts

Both the existing Gamsberg Zinc Mine and proposed Gamsberg Smelter Project are located in a designated CBA1 (see Figure 17). The direct footprint of the existing Gamsberg Zinc Mine pit, waste rock dump and tailings facility will occupy approximately 1 400 ha to which the proposed Gamsberg Smelter Project would add an additional 90 ha or 6.4%. Therefore, the Smelter Project footprint contributes a relatively small additional impact on the CBA1 and will not directly impact irreplaceable habitat or habitats of high conservation value.

The impacts from air emissions comprising particulates and gaseous emissions is more difficult to quantify as i) the extent of impact is only modelled and not verified by any in-field monitoring results so there is no certainty on the actual level of impact on vegetation likely to occur over time; and ii) the proposed Gamsberg Smelter Project emissions directly overlaps with the dust deposition zone modelled for the Gamsberg Zinc Mine which may intensify the expected impacts on vegetation. While the air quality impacts on vegetation from the Smelter Project largely remain within the modelled mine dust deposition footprints it is expected that the extent and intensity of impact would diminish along a gradient with increasing distance from the primary impact source (i.e. the smelter plant).

All of the proposed Gamsberg Smelter Project impacts on sensitive habitats within the CBA1 overlaps with the existing and future dust deposition impacts of the mine. Therefore, air emission-related impacts on vegetation generated by the Gamsberg Smelter Project is expected to result in impacts of increased intensity on the same habitats that have already been calculated as an area of total habitat loss for the Gamsberg Zinc Mine Biodiversity Offset. However, the 'new' calcrete gravel patch (occupying an area of approximately 100 ha) identified to the north of the proposed Gamsberg Smelter Project footprint was not quantified in the Gamsberg Zinc Mine offset within which sensitive flora could be impacted to some extent by air emissions, mainly SO_2 or NO_2, from the proposed Smelter Project as well as dust from mining. The risk of air emissions affecting this calcrete gravel patch is highly uncertain given that it falls within the 1-2 mg/m^3 annual concentration contour for SO_2 (Figure 23) (which is well under the global critical annual concentration value for lichens of 10 ug/m^3 a (CLRTAP 2017) and is situated a minimum 1.8 km from the smelter at its closest point.

The Gamsberg Zinc Mine offset process still needs to implement additional conservation actions to compensate for the loss or degradation of irreplaceable calcrete and quartz patches (which are also likely to be affected by the proposed Gamsberg Smelter Project) as per recommendations by Botha *et al.* (2013). It is recommended, therefore, that the 'new' 100 ha calcrete gravel patch is: i) further surveyed during optimal season to verify its conservation importance; ii) included in the flora monitoring plan to confirm air quality impacts (See Section 7), and iii) considered in any further recalculation of offset requirements.

It is essential that monitoring of the proposed Gamsberg Smelter Project impacts is detailed and included in the overall Gamsberg Zinc Mine monitoring programme and that this is fast-tracked to start obtaining a robust dataset to track changes to biodiversity over time and to verify the basis for the mine offset (see Section 7).

<u>Mitigation</u>

There is minimal effective mitigation for impacts on the CBA within which the Smelter Project is located. Applicable mitigation for vegetation impacts is listed in Sections 6.1.1, 6.1.2, 6.2.1, and 6.2.2.

<u>Significance of Impact</u>

The contribution of the proposed Gamsberg Smelter Project to cumulative impacts on CBAs and sensitive vegetation is assessed in Table 19.

Table 19. Contribution of proposed Gamsberg Smelter Project to cumulative impact of CBAs and sensitive vegetation

Impact Phase: Operation – Cumulative Impact							
Impact Description: Contribution of proposed Gamsberg Smelter Project to Cumulative Impacts on CBAs and Sensitive Vegetation							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**M**	**H**	**M**	**H**	**Medium**	**Medium**	**Low**
With Mitigation	**M**	**H**	**M**	**H**	**Medium**	**Medium**	**Low**
Can the impact be reversed?			No – the physical footprint and adjacent areas of the Smelter Project are unlikely to be possible to restore to its natural composition and condition.				
Will impact cause irreplaceable loss of resources?			Potentially, if there are significant impacts on the calcrete gravel patches from air emissions.				
Can impact be avoided, managed or mitigated?			Although the impact has been minimised through the selection of footprint locations that do not require clearance of sensitive areas, there is still likely to be some degree of unavoidable impact on irreplaceable habitats (e.g. calcrete gravel patches) and species of conservation concern from air emissions.				
Residual Impacts			Habitat degradation in the vicinity of the mine will last for the life of the mine as well as for decades thereafter as it is not likely that the site can be restored to its former condition.				

6.4.2 Contribution of the proposed Gamsberg Smelter Project to Cumulative Air Quality Impacts on Biodiversity Offsets Secured for the Gamsberg Zinc Mine

The modelled dust deposition for the Gamsberg Zinc Mine and proposed Gamsberg Smelter in relation to the Biodiversity Offsets secured to date for the mine are shown in Figure 27. As described in Section 3.4 and Section 6.2.1 the mine activities contributes significantly more dust deposition than predicted from the Gamsberg Smelter Project based on modelled results (Airshed 2020). The cumulative dust deposition for both projects (mine and smelter) have a similar 'modelled' area of influence although the Airshed 2020 model shows a shift in deposition to the east and south compared to the original air quality model for the mine (DDA 2013). This is due to model and parameter differences (see Section 3.4.2).

Of relevance to potential impacts on the existing Biodiversity Offset areas, results show that i) the cumulative impacts of dust deposition from the mine and smelter are not expected to impact the offset farms as modelled dust below the 20 mg/m^2/day threshold (used to calculate the mine's biodiversity offset) does not overlap offset farms secured to date; and ii) the cumulative dust deposition may however impact part of the set aside area remaining within the Gamsberg mining right, potentially impacting an additional 105 ha of irreplaceable habitat that falls outside the original 2013 modelled 20 mg/m^2/day threshold. Notwithstanding the differences in dust deposition between the 2013 and 2020 models, it is emphasised that any actual impacts from dust deposition will be generated primarily by the mine and not by the Smelter Project, which has a negligible influence on overall dust deposition.

As described in Section 6.2.2, modelled ground level concentrations of SO_2 at conservative thresholds of 2 ug/m^3/day (well under the critical value of 10 ug/m^3/day for lichens) falls within the 2013 modelled 20 mg/m^2/day dust deposition zone used to determine the mine offset. Therefore, no impact on secured offset areas for the Gamsberg Zinc Mine is expected to occur and no offset is specifically required for the Gamsberg Smelter Project.

In future, any recalculations of offset requirements for the Gamsberg Zinc Mine should take into consideration monitoring results which confirm actual impacts, rather than predicted impacts based on air quality models.

Mitigation

There is minimal effective mitigation for air quality impacts of the Gamsberg Zinc Mine and proposed Gamsberg Smelter Project.

As for Section 6.2.1 and 6.2.2, a comprehensive monitoring plan must be implemented to verify the project-related impacts of air quality on vegetation (see Section 7). If impacts due to the proposed Gamsberg Smelter Project become apparent over time, the project shall be required to investigate additional options that may be available over time to ensure the plant remains equipped with best available technology for air quality control to further mitigate air pollution impacts.

Significance of Impact

The contribution of the proposed Gamsberg Smelter Project to cumulative air quality impacts on Biodiversity Offset Areas for the Gamsberg Zinc Mine is assessed in Table 20.

Table 20. Contribution of the proposed Gamsberg Smelter Project to Cumulative Air Quality Impacts of Biodiversity Offset Areas for the Gamsberg Zinc Mine

Impact Phase: Operation – Cumulative Impact							
Impact Description: Contribution of the proposed Gamsberg Smelter Project to Cumulative Air Quality Impacts on Biodiversity Offset Areas for the Gamsberg Zinc Mine							
	Extent	**Duration**	**Intensity**	**Probability**	**Consequence**	**Significance**	**Confidence**
Without Mitigation	**VL**	**H**	**VL**	**L**	**Low**	**Negligible**	**Low**
With Mitigation	**VL**	**H**	**VL**	**L**	**Low**	**Negligible**	**Low**
Can the impact be reversed?			Not applicable. Air emission / dust deposition impacts of the proposed Smelter Project on offset areas (excluding set asides) is unlikely to occur. However, if the vegetation of the offset areas is impacted it would be unlikely to be reversible.				
Will impact cause irreplaceable loss of resources?			Unlikely. As above.				
Can impact be avoided, managed or mitigated?			No. No to limited mitigation for air quality impacts is possible. However, the offset areas are not predicted to be impacted by the proposed Gamsberg Smelter Project.				
Residual Impacts			No residual impacts on the offset areas from the proposed Gamsberg Smelter Project is expected.				

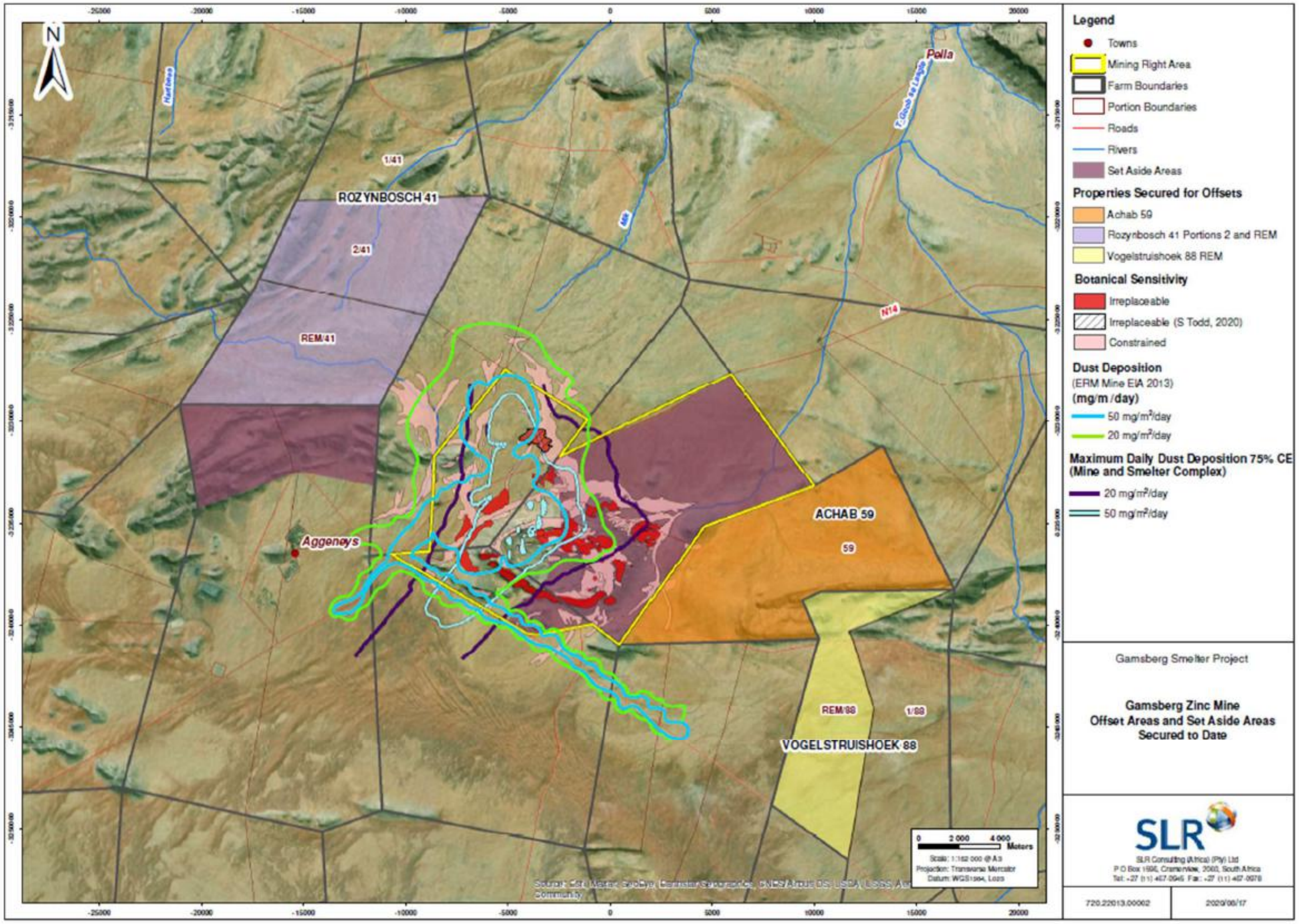


Figure 27. Modelled dust deposition of the Gamsberg Zinc Mine and the proposed Smelter Project (with 75% CE) relative to modelled dust deposition outputs for the Gamsberg Zinc Mine only relative to secured offset and set aside areas (Note: differences in the modelled outputs between the 2013 EIA and the 2020 Airshed model is because the meteorological data and model criteria are different (see Section 3.4.2). As a result, the Airshed 2020 model shows a shift in the 20 mg/m^2/day contour resulting in an additional 105 ha of irreplaceable habitat potentially being affected by dust deposition from the mine and smelter (most of which would be generated by the mine).

6.4.3 *Cumulative Impacts of Future Developments*

The potential for cumulative impacts on biodiversity in the wider Aggeneys area of the Northern Cape is a concern given the other planned developments that are taking place in this area or which may be attracted to the proposed Namaqua Spatial Economic Zone (SEZ). This includes both the expansion of the Gamsberg Zinc Mine which is already authorised and has a total footprint of approximately 1400 ha as well as increasing renewable energy projects planned for the wider area.

The Northern Cape Department of Economic Development and Tourism, in conjunction with the national Department of Trade and Industry (the DTI), is in the process of finalising submission documents for the declaration of a Namakwa Special Economic Zone to be established in the Aggeneys region of the Namakwa District of the Northern Cape Province (https://www.globalafricanetwork.com/investment-projects/catalyst-to-economic-growth-in-northern-cape-for-south-africa/ 12 June 2020). The anchor investor of the SEZ will be the Gamsberg Zinc Mine and the Smelter Project.

Key goals behind the establishment of SEZs are:

- To encourage industries to develop in clusters, leading to economies of scale, skills-sharing and easier access by suppliers
- To create industrial infrastructure to promote investment
- To promote cooperation between the public and private sectors
- To use the zones as a launching pad for other developments.

Additional area for the development of the above-mentioned industries in close proximity to the mine and smelter is likely to be required. This will result in additional pressure on the CBAs and their important biodiversity features in the area.

An estimated 9000 ha of renewable energy projects are also planned in the wider area, although it is uncertain how many will be constructed. It can be expected that approximately 2 000 ha of additional habitat loss may be affected by renewable projects[3]. The renewable energy projects are largely concentrated within the open plains habitat of the Bushmanland arid grassland vegetation type, which is a widespread habitat of low general diversity. The major corridors of the area, such as the Koa River valley south of the site and the inselberg mountain chains which includes the current area around Gamsberg Inselberg would not be impacted by renewable energy development but have been targeted by mining, with the Gamsberg Zinc Mine and Black Mountain Mines being the primary footprint areas.

The primary concern with regards to cumulative impact is the specific impact of the Gamsberg Zinc Mine on unique and rare habitats and their associated species. The proposed Smelter Project would

[3] Calculations derived from https://egis.environment.gov.za/data_egis/data_download/current

add approximately 90 ha to the expected mine footprint of 1400 ha, which is considered to represent a low contribution in terms of gross habitat loss. However, the SEZ is likely to require significantly greater area in close proximity to the mine and smelter and this is of particular concern given the important biodiversity of the area. A cumulative impact assessment and further investigation of offset requirements and potential options will be required once the potential footprint of the SEZ is confirmed.

6.5 Impact Assessment Summary

A summary of the assessed impacts associated with the proposed Gamsberg Smelter Project is provided below in Table 21.

Table 21. Summary assessment of ecological impacts associated with the proposed Gamsberg Smelter and SLF for each phase of the development before and after mitigation

Impact	Significance Before Mitigation	Significance After Mitigation
Construction Phase		
Impact on vegetation and flora due to site clearance	Medium	Medium
Impact on vegetation and flora due to construction related dust	Medium	Low
Impact on fauna due to site clearance	Medium	Medium
Impact on fauna due to construction phase noise and disturbance	Low	Low
Operational Phase		
Impact on vegetation due to dust deposition	Medium	Medium
Impact on vegetation due to changes in ambient air quality	Medium	Medium
Impact on vegetation due to groundwater contamination	Low	Low
Impact on fauna due to operational activities: dust, noise and disturbance	Medium	Low
Decommissioning Phase		
Ecological Degradation as a result of Decommissioning	Medium	Low
Contribution to Cumulative Impact		
Contribution of the proposed Smelter Project to Cumulative impacts on CBAs and Sensitive Habitats	Medium	Medium
Contribution of proposed Smelter Project to Cumulative Air Quality Impacts on Biodiversity Offset Areas for the Gamsberg Zinc Mine	Negligible	Negligible

7 MONITORING

Black Mountain Mining (BMM) has an existing Monitoring Plan with protocols for monitoring flora and dust (Desmet *et al* 2018); and priority fauna (Endemic Vision 2018) in the mine and offset areas which is envisaged to be continued for the life of mine and several years after mine closure. A key purpose of the flora monitoring is to confirm the extent of mine dust impacts on vegetation relative to rainfall and in so doing to attempt to validate the impact predictions of the air and groundwater models on vegetation. The flora and dust monitoring requires plot and transect surveys of vegetation in mine areas (impact sites) and offset areas (control sites) as well as collection of rainfall and dust deposition data in order to correlate weather and dust variables with vegetation condition in order to separate natural changes in vegetation condition from climate changes. It also recommends *ex-situ* research in off-site nursery areas involving experiments of dust effects on succulent plants with a focus on endemic flora as well as genetic studies on certain species. A summary of the monitoring framework is set out in Table 22 below.

Table 22. A summary of the spatial x temporal dimensions proposed for the monitoring the impacts of dust on the Bushmanland Inselberg Region (from Desmet *et al*. 2018)

Spatial Dimension	Temporal Dimension				
	Hourly / Daily	Monthly	Seasonal	Annual	Occasional
Landscape			Medium resolution (<10m) multispectral imagery (RGB, IR and hyperspectral, whole landscape)	High resolution (sub-meter) multispectral imagery (RGB and IR, Gamsberg only possibly Aggeneys)	
Monitoring Site *(Selected sites only)*	Automatic weather data (hourly)	Dust Sampling	Ultra-high resolution multi-spectral drone generated imagery		
Community *(The dominant plant community at each monitoring site at all sites as indicated in Figure 5)*			Fixed Point Photographs	Line transects (all sites)	Soil analysis (selected sites, baseline and every 5 years)Whittaker Plots (selected sites, baseline and every 5 years)
Species *in situ* *(Species of Conservation Concern and representative species from different leaf morphological/life history guilds)*	Time laps cameras (remote) phenology tracking (Selected sites) (daily)		Phenology tracking	Demography tracking	Populations genetic analysis
Species *ex situ* *(E.g. nursery)*	Plant performance observations (physiology, phenology and demography) under controlled experimental conditions				

Note: the reference to Figure 5 is contained in the Desmet *et al*. 2018 vegetation monitoring protocol.

Besides the uncertainty associated with the impact of dust from the existing mine that is covered by the existing monitoring framework (described above), there is additional uncertainty about the impact of other gaseous emissions (e.g. sulphur dioxide and nitrous oxides) and heavy metal fall out (e.g. lead and zinc) from the Smelter Project on vegetation, and particularly habitats and species of conservation concern. In order to contribute to research and knowledge on these potential effects, monitoring of air emissions on vegetation is considered an 'additional conservation action' that BMM should be required to implement as part compensation for its potential impacts on irreplaceable vegetation types in the Smelter Project area.

The existing flora monitoring plan (Desmet *et al*. 2018) needs to be expanded and developed to cover the monitoring requirements for the Smelter Project since the predicted impacts will occur in an overlapping area and will require similar research methods. Survey sites will need to be carefully selected to include areas of similar habitat types within the immediate vicinity of the smelter and SLF; sites within the modelled dust and air emission deposition zones; sites that may be affected by mining alone, and others in offset areas as control sites.
The minimum requirements that such a plan should address includes the following:

- A soil chemistry baseline should be established for the various vegetation monitoring sites as a baseline for periodic monitoring of potential substrate-related changes in soil chemistry, possibly at five-year intervals. This should include samples of soil texture and composition from the different soil and substrate types that may be affected by particulates (dust), heavy metals deposition and gaseous emissions. The baseline should be used to evaluate the impact of the smelter (and mine) on soil chemistry and provide insight into the pathways of impact on plants.

- Verify the location of existing dust monitoring sites and adjust or add new dust monitoring sites in proximity to the selected vegetation monitoring sites. The dust monitoring programme should be evaluated to ascertain whether there are sufficient monitoring stations to accurately evaluate levels of particulate and metal deposition, and gaseous concentrations within sensitive habitats such as the calcrete gravel patches. The composition of the dust should be regularly analysed for correlation with soil chemistry and potential flora/ vegetation changes.

- A targeted plant species monitoring programme should be established to monitor the population dynamics of selected indicator and endemic species. Potential species that should be monitored include *Lithops* spp., *Conophytum* spp. *Titanopsis hugo-schlechteri*, *Anacampseros bayeri* and *Crassula mesembrianthemopsis*. These are potentially sensitive species or indicator species associated with the calcrete and/or quartz gravel patches and should be monitored both in areas where there is expected to be an impact as well as adjacent areas where there is expected to be no impact from mining or the Smelter Project. Annual monitoring should be sufficient, but it is important that this is done following adequate rains each year when the target species are active and easier to locate and count. Setting up permanent monitoring sites or quadrats is considered a useful approach as most of the species mentioned above are cryptic species that can be hard to locate even during the optimal season (January to April).

- The detailed monitoring plan will need to clearly define the monitoring sites, species indicators, expected outcomes, survey methods, data analysis, including correlation of data across sites and between different variables. It should try and define specific indicators (such as percentage change in presence / cover) that should trigger additional investigation or actions.

- Monitoring results should be routinely presented to mine management and to DENC to facilitate awareness and to leverage additional actions that may be required to further reduce or avoid impact on plant species of conservation concern and their habitats or to revaluate offset requirements.
- A Monitoring Report should be published annually and made publicly available.

8 CONCLUSIONS & RECOMMENDATIONS

The proposed Gamsberg Smelter Project is situated adjacent to the existing Gamsberg Zinc Mine within a Critical Biodiversity Area Category 1 (CBA1) designated primarily for threatened and range-restricted flora and plant communities. The presence of the mine has been taken into consideration when undertaking this ecological impact assessment.

The proposed Smelter Project included three alternative locations for the smelter (SM1-3) and for the SLF (SLF1-3), two SLF and one Smelter locations in CBA2 and two smelter locations and one SLF in CBA1 (closer to the Gamsberg Inselberg). SLF2 is considered fatally-flawed as it impinges on the newly identified calcrete gravel area with a rare plant community with confirmed SCC present. SLF1 was identified as the preferred alternative from an ecological perspective as it is located in a widespread arid grassland habitat type to the north of the road. However, SLF3 was selected as the preferred location of the developer for technical and traffic safety considerations to avoid having to truck or move product across the main road. While the smelter location to the north of the road was preferred for ecological reasons, the two southerly smelter locations (SM2 and SM3) are considered 'marginally acceptable'. This is because the selected Smelter and SLF sites are close to irreplaceable calcrete gravel patches, and the SLF site is close to an ephemeral stream course and had intact faunal habitat. Within these areas, the abundance of species or habitats of concern is low and no residual impacts of high significance on biodiversity is expected from the construction of the smelter and SLF at these sites.

Although the project area lies within a CBA1, the open plains of the preferred sites for the proposed Gamsberg Smelter Project are assessed as medium sensitivity and the residual impact of vegetation clearance within the 90-ha footprint is assessed as medium significance. Within the typical flat sandy plains habitat of the project footprint the abundance of species of conservation concern is relatively low, although some protected and red-listed species such as *Hoodia gordonii* and *Aloidendron dichotomum* (VU) are present at a relatively low density. The sensitivity mapping produced for this assessment largely supports the previous ecological work and mapping in the area but has identified an additional calcrete gravel patch of 100 ha near SLF2 that was not previously delineated in earlier mapping.

Fauna in the proposed Gamsberg Smelter Project area are generally widespread species, none of high conservation concern, and which are already expected to have been impacted by the noise and disturbance from existing mining activities. Impacts on faunal habitat through site clearance is assessed as medium significance, while residual impacts on fauna from construction activities is assessed as low significance.

The impact of gaseous emissions, dust and heavy metal deposition from the smelter on vegetation around the proposed Smelter Project is highly uncertain. However, all modelled air quality impacts from the proposed Gamsberg Smelter Project for conservative vegetation thresholds are predicted to fall within the dust depositional area from the Gamsberg Zinc Mine which was used as the basis for quantifying the mine's existing biodiversity offset requirements. The offset was based on 100% habitat loss within the modelled dust depositional areas of 50 mg/m^2/day and 100% habitat loss of all irreplaceable habitats in the 20 mg/m^2/day dust deposition area. Therefore the impact of air emissions and vegetation loss associated with the proposed Gamsberg Smelter Project has already been accounted for in the mine offset calculations. Therefore, no further offset for the proposed Smelter Project is deemed to be necessary.

Nonetheless, given: i) the uncertainty on the predicted residual air quality impacts on vegetation; ii) the lack of sufficient monitoring to confirm the impact of current mine dust on vegetation, and iii) the fact the existing mine offset has not compensated fully for predicted dust impacts on irreplaceable habitats such as calcrete patches, it is incumbent on BMM to implement strict mitigation measures to minimise biodiversity impacts; to implement the full mine offset requirements (including compensation for calcrete patches), and to start detailed monitoring to better understand the air quality impacts on vegetation and to verify the basis for the mine offset.

Apart from the direct and indirect impacts of the proposed Gamsberg Smelter Project, it will be important for the various relevant authorities to consider possible future cumulative impacts on biodiversity in the immediate area of the Gamsberg Zinc Mine. This is not only because of the Smelter Project but also the intended Namakwa Special Economic Zone (SEZ) and various renewable energy projects. It is strongly advised that some form of strategic planning be undertaken to ensure the balance between the protection of the threatened and range restricted flora (within the Critical Biodiversity Areas) and the promotion of the much-needed economic development and associated socioeconomic benefits that this will bring to the Northern Cape.

Impact Statement:

In summary, the proposed Gamsberg Smelter Project footprint is situated within close proximity to the existing operational Gamsberg Zinc Mine, both of which are in a CBA1. The existing Gamsberg Zinc Mine is predicted to have significantly larger adverse impacts on biodiversity relative to the proposed Gamsberg Smelter Project both in terms of footprint and direct loss of sensitive habitats, as well as dust deposition on vegetation. There are no features of very high biodiversity importance or which could be considered irreplaceable within the direct footprint of the proposed Gamsberg Smelter Project. Dust and other pollutants produced as a result of the proposed Smelter Project operation are, however, likely to impact the surrounding vegetation which is a potential concern given the high biodiversity value of some habitats and species in the immediate area, notably calcrete gravel patches. However, the existing Biodiversity Offset for the Gamsberg Zinc Mine has catered for the predicted impacts associated with the proposed Smelter Project and therefore no additional offset is required to compensate for the predicted residual impacts. The relative contribution of the proposed Smelter Project to cumulative impacts would be low and is considered acceptable. Based on the layout and alternatives provided for the assessment, the Gamsberg Smelter Project is considered acceptable from a terrestrial ecology point of view, subject to the strict implementation of the mitigation and monitoring requirements described in this report.

9 REFERENCES

Alexander, G. & Marais, J. 2007. A Guide to the Reptiles of Southern Africa. Struik Nature, Cape Town.

Airshed 2020a. Air Quality Impact Assessment for the for the Gamsberg Smelter Project. Compiled by Airshed Planning Professionals for SLR.

Fitzpatrick Institute of Africa Ornithology, Virtual Museum. database (http://vmus.adu.org.za/). Coordinated by the Avian Demography Unit.

Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J. & de Villiers, M. S. 2014. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Strelitzia 32. SANBI, Pretoria.

Botha, M, Desmet P and Brownlie, S. 2013. Draft Scope Biodiversity Offset Study. Report for Gamsberg Mine EIA by ERM.

Branch W.R. 1998. Field guide to snakes and other reptiles of southern Africa. Struik, Cape Town.

CLRTAP, 2017. Mapping Critical Levels for Vegetation, Chapter III of Manual on methodologies and criteria for modelling and mapping critical loads and levels and air pollution effects, risks and trends. UNECE Convention on Long-range Transboundary Air Pollution; accessed on [July 2020] on Web at www.icpmapping.org.

Department of Environmental Affairs (2016) National Protected Areas Expansion Strategy for South Africa 2016. Department of Environmental Affairs, Pretoria, South Africa.

Desmet, P. 2013. Vegetation baseline and impact assessment report: Gamsberg Zinc Mine. Report for ERM. Specialist report Annex G5 for EIA.

Desmet, P.G., Yates, M and Botha, M. (2005). Bushmanland Conservation Initiative - Spatial Data Report. Dated August 30, 2005.

Desmet, PG, Schmiedel, U and le Roux, A. 2018. Gamsberg Zinc Project: Biodiversity Monitoring Framework For Species Of Conservation Concern And Dust Impacts. Report for Endemic Vision on behalf of Black Mountain Mine 23 August 2018.

Du Preez, L. & Carruthers, V. 2009. A Complete Guide to the Frogs of Southern Africa. Struik Nature., Cape Town.

Endemic Vision, 2018. Black Mountain Mine Monitoring Protocol Framework: Fauna of Conservation Concern. Report for Black Mountain Mine.

EWT & SANBI, 2016. Red List of Mammals of South Africa, Lesotho and Swaziland. EWT, Johannesburg.

Friedmann and Daly (2004). Red Data Book of the Mammals of South Africa – a conservation assessment. Published by Endangered Wildlife Trust and IUCN.GroundTruth, 2013. Terrestrial Fauna and Aquatic Biodiversity. Report for proposed Zinc Mine on Gamsberg, Northern Cape. Report for ERM. Specialist report Annex G4 for EIA.

IUCN (2020). IUCN Red List. www.iucnredlist.org

Marais, J. 2004. Complete Guide to the Snakes of Southern Africa. Struik Nature, Cape Town.

Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and Nienaber, S. (2011). Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

Minter LR, Burger M, Harrison JA, Braack HH, Bishop PJ & Kloepfer D (eds). 2004. Atlas and Red Data book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB Series no. 9. Smithsonian Institution, Washington, D.C.

Mucina L. & Rutherford M.C. (eds) 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Oosthuysen, E. & Holness, S. 2016. Northern Cape Critical Biodiversity Areas (CBA) Map. Northern Cape Department of Environment and Nature Conservation & Nelson Mandela Metropolitan University. Available at SANBI BGIS http://bgis.sanbi.org/.

Påhlsson, A. M. B. (1989). Toxicity of heavy metals (Zn, Cu, Cd, Pb) to vascular plants. *Water, Air, and Soil Pollution*, *47*(3-4), 287-319.

Sharma, P., & Dubey, R. S. (2005). Lead toxicity in plants. *Brazilian journal of plant physiology*, *17*(1), 35-52.

SANBI (2020). Threatened Species Programme, Red List of South African Plants Online (2020). Available at http://redlist.sanbi.org/index.php

Seymour, C. L., Milton, S. J., Altwegg, R., Joseph, G. S., & Dean, W. R. J. (2020). Addition of Nitrogen Increases Variability of Vegetation Cover in an Arid System with Unpredictable Rainfall. *Ecosystems*, *23*(1), 175-187.

Skinner, J.D. & Chimimba, C.T. 2005. The mammals of the Southern African Subregion. Cambridge University Press, Cambridge.

SLR 2020a. Hydrogeological assessment for Gamsberg Smelter Project. Specialist report for EIA.

SLR 2020b. Surface water assessment for Gamsberg Smelter Project. Specialist report for EIA.

SRK, 2009. Gamsberg Zinc Project. Draft Baseline Climate and Air Quality Report. Report Prepared for Gamsberg Pre-Feasibility Project. Report No 396036/Air/1. December 2009

Todd, S. 2013. Fauna and Flora Specialist Report for ESIA of Gamsberg Zine Mine. Report for ERM. Specialist report Annex G6 for EIA.

10 APPENDICES

10.1 Appendix 1. Profile and CV of Specialist

Simon Todd is Director and principal scientist at 3Foxes Biodiversity Solutions and has over 20 years of experience in biodiversity measurement, management and assessment. He has provided specialist ecological input on more than 200 different developments distributed widely across the country. This includes input on the Strategic Environmental Assessment (SEA) for Wind and Solar Photovoltaic (PV) Energy in South Africa (CSIR, 2015) as well as the Eskom Grid Infrastructure (EGI) SEA and Karoo Shale Gas SEA. He is on the National Vegetation Map Committee as a representative of the Nama and Succulent Karoo Biomes. Simon Todd is a recognised ecological expert and is a past chairman and current deputy chair of the Arid-Zone Ecology Forum. He is registered with the South African Council for Natural Scientific Professions (SACNASP: No. 400425/11). A selection of recent work is as follows:

Strategic Environmental Assessments

- Co-Author: Chapter 7 - Biodiversity & Ecosystems - Shale Gas SEA. CSIR 2016.
- Co-Author: Chapter 1 Scenarios and Activities – Shale Gas SEA. CSIR 2016.
- Co-Author: – Ecological Chapter – Wind and Solar SEA. CSIR 2014.
- Co-Author: Ecological Chapter – Eskom Grid Infrastructure SEA. CSIR 2015.
- Contributor: Ecological & Conservation components to SKA SEA. CSIR 2017.

Recent Specialist Ecological Studies in the Vicinity of the Current Site

- Gamsberg Biodiversity Monitoring Project - Fauna Specialist Study. ERM 2017.
- Proposed Establishment of the Gamsberg Zinc Mine, Concentrator Plant and Associated Infrastructure Near the Town of Aggeneys, Northern Cape. Fauna & Flora Specialist Report for ESIA. ERM, 2013.
- EIA Process for the Proposed Expansion of the Swartberg Mine in Aggeneys, Northern Cape, South Africa. Fauna Specialist Study. ERM 2019.
- Pella Water Board – Infrastructure Upgrade. Fauna & Flora Specialist Report for Basic Assessment. ERM, 2013.
- Basic Assessment for the Proposed Aggeneys 1 & 2 SEFs and Associated Infrastructure. Fauna & Flora Specialist Study. Savannah Environmental 2019.

- Environmental Impact Assessment for the Proposed Enamandla PV1, PV2 & PV3 Solar Power Plants: Fauna & Flora Specialist Assessment. WSP Environmental 2017.

10.2 Appendix 2. Impact Assessment Methodology

PART A: DEFINITIONS AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of intensity, spatial extent and duration**
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE							
			EXTENT				
			A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
			VL	L	M	H	VH
INTENSITY = VL							
DURATION	Very long	VH	Low	Low	Medium	Medium	High
	Long term	H	Low	Low	Low	Medium	Medium
	Medium term	M	Very Low	Low	Low	Low	Medium
	Short term	L	Very low	Very Low	Low	Low	Low
	Very short	VL	Very low	Very Low	Very Low	Low	Low
INTENSITY = L							
DURATION	Very long	VH	Medium	Medium	Medium	High	High
	Long term	H	Low	Medium	Medium	Medium	High
	Medium term	M	Low	Low	Medium	Medium	Medium
	Short term	L	Low	Low	Low	Medium	Medium
	Very short	VL	Very low	Low	Low	Low	Medium
INTENSITY = M							
DURATION	Very long	VH	Medium	High	High	High	Very High
	Long term	H	Medium	Medium	Medium	High	High
	Medium term	M	Medium	Medium	Medium	High	High
	Short term	L	Low	Medium	Medium	Medium	High
	Very short	VL	Low	Low	Low	Medium	Medium
INTENSITY = H							
DURATION	Very long	VH	High	High	High	Very High	Very High
	Long term	H	Medium	High	High	High	Very High
	Medium term	M	Medium	Medium	High	High	High
	Short term	L	Medium	Medium	Medium	High	High
	Very short	VL	Low	Medium	Medium	Medium	High
INTENSITY = VH							
DURATION	Very long	VH	High	High	Very High	Very High	Very High
	Long term	H	High	High	High	Very High	Very High
	Medium term	M	Medium	High	High	High	Very High
	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	VH	Very Low	Low	Medium	High	Very High
	Probable	H	Very Low	Low	Medium	High	Very High
	Possible/ Frequent	M	Very Low	Very Low	Low	Medium	High
	Conceivable	L	Insignificant	Very Low	Low	Medium	High
	Unlikely/ improbable	VL	Insignificant	Insignificant	Very Low	Low	Medium
			VL	L	M	H	VH

CONSEQUENCE

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

10.4 Appendix 4. List of Mammals

List of mammals which are likely to occur in the vicinity of the site based on the literature. Habitat notes and distribution records are based on Skinner & Chimimba (2005), while conservation status is from the IUCN Red Lists 2015 and South African Red Data Book for Mammals (Friedmann & Daly 2004).

Scientific Name	Common Name	Status	Habitat	Likelihood
Macroscledidea (Elephant Shrews):				
Macroscelides proboscideus	Round-eared Elephant Shrew	LC	Species of open country, with preference for shrub bush and sparse grass cover, also occur on hard gravel plains with sparse boulders for shelter, and on loose sandy soil provided there is some bush cover	Confirmed
Elephantulus rupestris	Western Rock Elephant Shrew	LC	Rocky koppies, rocky outcrops or piles of boulders where these offer sufficient holes and crannies for refuge.	Low
Tubulentata:				
Orycteropus afer	Aardvark	LC	Wide habitat tolerance, being found in open woodland, scrub and grassland, especially associated with sandy soil	Confirmed
Hyracoidea (Hyraxes)				
Procavia capensis	Rock Hyrax	LC	Outcrops of rocks, especially granite formations and dolomite intrusions in the Karoo. Also erosion gullies	Confirmed
Lagomorpha (Hares and Rabbits):				
Pronolagus rupestris	Smith's Red Rock Rabbit	LC	Confined to areas of krantzes, rocky hillsides, boulder-strewn koppies and rocky ravines	Confirmed
Lepus capensis	Cape Hare	LC	Dry, open regions, with palatable bush and grass	Confirmed
Rodentia (Rodents):				
Hystrix africaeaustralis	Cape Porcupine	LC	Catholic in habitat requirements.	Confirmed
Petromus typicus	Dassie Rat	LC	Mountainous regions and inselbergs, where they are confined to rocky outcrops and live in crevices or piles of boulders	High
Xerus inauris	South African Ground Squirrel	LC	Open terrain with a sparse bush cover and a hard substrate	Confirmed
Graphiurus platyops	Rock Dormouse	LC	Rocky terrain, under the exfoliation on granite bosses, and in piles of boulders	Low
Rhabdomys pumilio	Four-striped Grass Mouse	LC	Essentially a grassland species, occurs in wide variety of habitats where there is good grass cover.	High
Thallomys paedulcus	Acacia Tree Rat	LC	Associated with stands of Acacia woodland	Low
Thallomys nigricauda	Black-tailed Tree Rat	LC	Associated with stands of Acacia woodland	Low
Aethomys namaquensis	Namaqua Rock Mouse	LC	Catholic in their habitat requirements, but where there are rocky koppies, outcrops or boulder-strewn hillsides they use these preferentially	Confirmed
Parotomys brantsii	Brants' Whistling Rat	LC	Associated with a dry sandy substrate in more arid parts of the Nama-karoo and Succulent Karoo. Species selects	High

Scientific Name	Common Name	Status	Habitat	Likelihood
			areas of low percentage of plant cover and areas with deep sands.	
Parotomys littledalei	Littledale's Whistling Rat	LC	Riverine associations or associated with Lycium bushes or Psilocaulon absimile	High
Desmodillus auricularis	Cape Short-tailed Gerbil	LC	Tend to occur on hard ground, unlike other gerbil species, with some cover of grass or karroid bush	High
Gerbillurus paeba	Hairy-footed Gerbil	LC	Gerbils associated with Nama and Succulent Karoo preferring sandy soil or sandy alluvium with a grass, scrub or light woodland cover	Confirmed
Gerbillurus tytonis	Dune Hairy-footed Gerbil	LC	Hot dry areas on shifting red sand dunes	High
Gerbilliscus leucogaster	Bushveld Gerbil	LC	Predominantly associated with light sandy soils or sandy alluvium	Moderate
Gerbilliscus brantsii	Higheld Gerbil	LC	Sandy soils or sandy alluvium with some cover of grass, scrub or open woodland	Moderate
Saccostomus campestris	Pouched Mouse	LC	Catholic habitat requirements, commoner in areas where there is a sandy substrate.	High
Malacothrix typica	Gerbil Mouse	LC	Found predominantly in Nama and Succulent Karoo biomes, in areas with a mean annual rainfall of 150-500 mm.	High
Petromyscus collinus	Pygmy Rock Mouse	LC	Arid areas on rocky outcrops or koppies with a high rock cover	High
Pedetes capensis	Springhare	LC	Short grassy areas, sparse vegetation and sandy soils in which to burrow	Confirmed
Primates:				
Papio ursinus	Chacma Baboon	LC	Can exploit fynbos, montane grasslands, riverine courses in deserts, and simply need water and access to refuges.	Confirmed
Cercopithecus mitis	Vervet Monkey	LC	Most abundant in and near riparian vegetation of savannahs	Low
Eulipotyphla (Shrews):				
Crocidura cyanea	Reddish-Grey Musk Shrew	LC	Occurs in relatively dry terrain, with a mean annual rainfall of less than 500 mm. Occur in karroid scrub and in fynbos often in association with rocks.	High
Carnivora:				
Proteles cristata	Aardwolf	LC	Common in the 100-600mm rainfall range of country, Nama-Karoo, Succulent Karoo Grassland and Savanna biomes	Confirmed
Caracal caracal	Caracal	LC	Caracals tolerate arid regions, occur in semi-desert and karroid conditions	Confirmed
Felis silvestris	African Wild Cat	LC	Wide habitat tolerance.	Confirmed
Panthera pardus	Leopard	NT	Wide habitat tolerance, associated with areas of rocky koppies and hills, mountain ranges and forest	Low

Scientific Name	Common Name	Status	Habitat	Likelihood
Felis nigripes	Black-footed cat	VU	Associated with arid country with MAR 100-500 mm, particularly areas with open habitat that provides some cover in the form of tall stands of grass or scrub.	High
Genetta genetta	Small-spotted genet	LC	Occur in open arid associations	Confirmed
Suricata suricatta	Meerkat	LC	Open arid country where substrate is hard and stony. Occur in Nama and Succulent Karoo but also fynbos	Confirmed
Cynictis penicillata	Yellow Mongoose	LC	Semi-arid country on a sandy substrate	Confirmed
Herpestes pulverulentus	Cape Grey Mongoose	LC	Wide habitat tolerance	High
Atilax paludinosus	Marsh Mongoose	LC	Associated with well-watered terrain, living in close association with rivers, streams, marshes, etc.	Low
Vulpes chama	Cape Fox	LC	Associated with open country, open grassland, grassland with scattered thickets and coastal or semi-desert scrub	Confirmed
Canis mesomelas	Black-backed Jackal	LC	Wide habitat tolerance, more common in drier areas.	Confirmed
Otocyon megalotis	Bat-eared Fox	LC	Open country with mean annual rainfall of 100-600 mm	Confirmed
Aonyx capensis	African Clawless Otter	LC	Predominantly aquatic and do not occur far from permanent water	Low
Ictonyx striatus	Striped Polecat	LC	Widely distributed throughout the sub-region	High
Rumanantia (Antelope):				
Tragelaphus strepsiceros	Greater Kudu	LC	Broken, rocky terrain with a cover of woodland and a nearby water supply.	Low
Oryx gazella	Gemsbok	LC	Open arid country	Confirmed
Sylvicapra grimmia	Common Duiker	LC	Presence of bushes is essential	Confirmed
Antidorcas marsupialis	Springbok	LC	Arid regions and open grassland.	Confirmed
Raphicerus campestris	Steenbok	LC	Inhabits open country,	Confirmed
Oreotragus oreotragus	Klipspringer	LC	Closely confined to rocky habitat.	Confirmed

10.5 Appendix 5. List of Reptiles

List of reptiles which are likely to occur at the site, based on the ReptileMap database of the Avian Demography Unit at the University of Cape Town. Conservation status is from Bates *et al*. (2014).

Family	Genus	Species	Subspecies	Common name	Red list category	Number of records
Agamidae	*Agama*	*atra*		Southern Rock Agama	Least Concern	2
Agamidae	*Agama*	*knobeli*		Knobel's Rock Agama	Not listed	1
Colubridae	*Dasypeltis*	*scabra*		Rhombic Egg-eater	Least Concern	2
Colubridae	*Dipsina*	*multimaculata*		Dwarf Beaked Snake	Least Concern	3
Colubridae	*Telescopus*	*beetzii*		Beetz's Tiger Snake	Least Concern	2
Cordylidae	*Karusasaurus*	*polyzonus*		Karoo Girdled Lizard	Least Concern	2
Cordylidae	*Platysaurus*	*capensis*		Namaqua Flat Lizard	Least Concern	1
Elapidae	*Aspidelaps*	*lubricus*	*lubricus*	Coral Shield Cobra	Not listed	6
Elapidae	*Naja*	*nigricincta*	*woodi*	Black Spitting Cobra	Least Concern	1
Elapidae	*Naja*	*nivea*		Cape Cobra	Least Concern	2
Gekkonidae	*Chondrodactylus*	*angulifer*	*angulifer*	Common Giant Ground Gecko	Least Concern	4
Gekkonidae	*Chondrodactylus*	*bibronii*		Bibron's Gecko	Least Concern	7
Gekkonidae	*Goggia*	*lineata*		Striped Pygmy Gecko	Least Concern	4
Gekkonidae	*Pachydactylus*	*goodi*		Good's Gecko	Vulnerable	1
Gekkonidae	*Pachydactylus*	*latirostris*		Quartz Gecko	Least Concern	8
Gekkonidae	*Pachydactylus*	*weberi*		Weber's Gecko	Least Concern	1
Gerrhosauridae	*Cordylosaurus*	*subtessellatus*		Dwarf Plated Lizard	Least Concern	1
Lacertidae	*Meroles*	*suborbitalis*		Spotted Desert Lizard	Least Concern	7
Lacertidae	*Nucras*	*tessellata*		Western Sandveld Lizard	Least Concern	1
Lacertidae	*Pedioplanis*	*lineoocellata*	*lineoocellata*	Spotted Sand Lizard	Least Concern	1
Lacertidae	*Pedioplanis*	*namaquensis*		Namaqua Sand Lizard	Least Concern	8
Lamprophiidae	*Boaedon*	*capensis*		Brown House Snake	Least Concern	3
Lamprophiidae	*Psammophis*	*namibensis*		Namib Sand Snake	Least Concern	1
Lamprophiidae	*Psammophis*	*notostictus*		Karoo Sand Snake	Least Concern	1
Lamprophiidae	*Pseudaspis*	*cana*		Mole Snake	Least Concern	1
Scincidae	*Acontias*	*namaquensis*		Namaqua Legless Skink	Least Concern	1
Scincidae	*Acontias*	*tristis*		Namaqua Dwarf Legless Skink	Least Concern	23
Scincidae	*Trachylepis*	*occidentalis*		Western Three-striped Skink	Least Concern	1
Scincidae	*Trachylepis*	*sulcata*	*sulcata*	Western Rock Skink	Least Concern	2
Scincidae	*Trachylepis*	*variegata*		Variegated Skink	Least Concern	2
Testudinidae	*Homopus*	*signatus*		Speckled Padloper	Vulnerable	1
Testudinidae	*Psammobates*	*tentorius*	*verroxii*	Verrox's Tent Tortoise	Not listed	13
Typhlopidae	*Rhinotyphlops*	*schinzi*		Schinz's Beaked Blind Snake	Least Concern	1
Viperidae	*Bitis*	*arietans*	*arietans*	Puff Adder	Least Concern	1
Viperidae	*Bitis*	*caudalis*		Horned Adder	Least Concern	2

10.6 Appendix 6. List of Amphibians

List of amphibians which are likely to occur in the vicinity of the site. Based on the Frogmap database, while conservation status is from the IUCN Red Lists 2014 and Minter *et al.* (2004).

Family	Genus	Species	Common name	Red list category	No. records
Bufonidae	*Vandijkophrynus*	*gariepensis*	Karoo Toad (subsp. gariepensis)	Not listed	2
Bufonidae	*Vandijkophrynus*	*robinsoni*	Paradise Toad	Least Concern	10
Microhylidae	*Phrynomantis*	*annectens*	Marbled Rubber Frog	Least Concern	7
Pipidae	*Xenopus*	*laevis*	Common Platanna	Least Concern	1
Pyxicephalidae	*Amietia*	*fuscigula*	Cape River Frog	Least Concern	4
Pyxicephalidae	*Cacosternum*	*namaquense*	Namaqua Caco	Least Concern	3
Pyxicephalidae	*Strongylopus*	*springbokensis*	Namaqua Stream Frog	Vulnerable	2
Pyxicephalidae	*Tomopterna*	*delalandii*	Cape Sand Frog	Least Concern	3

10.7 Appendix 7. Background Research on dust and ambient air quality impacts

The table below summarises the key points with relevance to air quality impacts on vegetation. There is very little useful information available with relevance to air quality impacts of similar Smelter Projects in arid environments that can be used to determine critical values or thresholds for desert succulent vegetation. A key problem when interpreting the source information is standardising for units of measurement, vegetation types, and interactive factors such as climate (air moisture, wind, rainfall), and soil type amongst other variables.

Variable	Effects	Notes	Authors
Dust	• Reduced photosynthesis due to shading	• Impact increases as particle size decreases.	Hirano *et al*., 1995; Squires 2016.
	• Physical leaf damage from abrasion • Physical leaf damage from chemical injury due to strongly acidic or alkaline materials	• Increases absorption of other atmospheric pollutants.	Farmer, 1993; Doley, 2006; Prajapati & Tripathi, 2008; Kerstiens, 1996; Squires 2016; Turner *et al.* 2013.
	• Increased leaf temperature (by 2 to 4 °C)	• Decreases photosynthesis rate. • Increased numbers of bacteria and fungi. • Increased water loss through transpiration. • Dependent on particle size and colour with dark colours and smaller particle size impacting measurably at lower surface loads.	Farmer, 1993; Khan *et al*. 2016; Naidoo & Chirkoot, 2004; Prajapati & Tripathi, 2008 Nanos and Ilias, 2007; Squires 2016; Thompson *et al.* 1984; Botha, 2002.
	• May block stomata.	• Interferes with diffusion of gases into and out of leaves.	Farmer, 1993; Doley, 2006; Flückiger et al. 1979; Prajapati, 2012; Naidoo & Chirkoot, 2004; Prajapati & Tripathi, 2008; Prusty *et al*., 2005; Santosh & Tripathi, 2008 in Squires 2016.
	• May change pH of soil	• Dependent on dust composition	Farmer, 1993.
	Threshold of measurable impact: • Between 1 and 8 g/m^2 for all studies. • Deposition rates of 0.03 to 6.3 $g/m^2/day$ (on trees).	• Varies with dust characteristics (particle size, colour, pH, reactivity). • Varies with leaf characteristics such as hairiness, orientation and size, which impact dust retention. • Varies with wind velocity and moisture.	Farmer, 1993; Matsuki *et al*. 2016; Squires, 2016; Saebo *et al.,* 2012.
Heavy Metals	• Phytotoxicity - Pb, Zn, Cu Cd, Fe • Zn - Stunted root and shoot growth and chlorosis of new leaves. • Pb - Adverse effects on plant morphology, growth and photosynthesis.	• Leads to changes in vegetation structure and composition. • Annuals, herbaceous perennials, grasses, cacti and some shrubs found to be most impacted in Arizona desert study near smelter (Wood and Nash, 1976). • Variation in toxicity leads to changes in species composition.	Ettler *et al.* 2016 Kapusktka *et al.*, 1995; Manz & Castro, 1997; Wood and Nash, 1976; Kabata-Pendias & Pendias, 2001; Reddy *et al.,* 2005.

Variable	Effects	Notes	Authors
	Thresholds of measurable impact: Zn • Cytological disorders from 100 to 200 ug/l. • Plant growth affected from 1000 ug/l.	• Thresholds approx. 10x higher than Cu or Cd. • Plants may adapt to high zinc soils over time. • Decreased toxicity in alkaline soils. • Grasses more sensitive than dicots in alkaline soils. • Natural background levels in RSA between 12 and 115 mg/kg.	Pahlsson, 1989; Titshall *et al*. 2013; Chaney 1993.
	Thresholds of measurable impact: Pb • None determined for air quality. • 100 mg/kg (~ 100,000 mg/m^3) in soil for natural ecosystems (DEA 2013: RSA Norms and Standards - GN 467 of 2013).	• Deposition rates vary widely. • Dependent on buffering effect of soil. • Impact is greater in acidic soils. • Thresholds are difficult to determine. • 150 mg/kg impacts growth rates of certain succulents and pelargoniums in arid Australia (Zhang *et al*. 2015). • Natural background levels in RSA between 2.99 and 65.8 mg/kg.	Blake & Goulding, 2002; Milton *et al.* 2002; Pahlsson, 1989; Zhang *et al.,* 2015; DEA, 2013; Herselman *et al*. 2005.
SO_2	• Acidic precipitation	• Leads to decreased soil pH and nutrient deficiency (especially Mg and K). • Leads to increased aluminium concentration which causes root damage. • Erodes epistomatal waxes increasing permeability and impact from other pollutants. • Variation in sensitivity can change community structure. • Solute concentration in mist may be up to 10 times that of rain. • Combined impact with NOx.	Lukewille & Alewell, 2008; WHO, 2000; Botha, 2002.
	• Disrupts photosynthesis • Usually causes stomata to open resulting in water loss and exposure to other pollutants (particularly NOx). • May cause stomatal closure in some cases resulting in protection from other pollutants but slowing photosynthesis. • Used in protein synthesis in small quantities favouring certain species.	• Reduced plant growth rate and reduced quality of plant yield in most plants. • Response varies and resistant plants are favoured. • Foliar necrosis at higher concentrations after even short durations. • Physical damage noted up to 50 km from source with severe damage within 8 km - concentration dependent.	Gheorge & Ion, 2011; Botha, 2002; WHO, 2000; Dueck *et al.* 1992.
	• May increase growth rates and performance of aphids (a common agricultural pest).		Dohmen *et al*. 1984; McNeill *et al.* 1990.
	Critical Levels: • 10 ug/m^3 - cyanobacterial lichens	• Threshold values exclude information from arid environments and applicability is not certain. However,	CLRTAP, 2017.

Variable	Effects	Notes	Authors
	• 20 ug/m³ - Forest, natural and semi-natural ecosystems • 30 ug/m³ - Crops	lichens are most likely the most sensitive taxon globally. • Community changed have been observed below 10 ug/m³. • 30 ug/m³ is sufficient to eradicate most sensitive cryptogam taxa. • One probabilistic study indicated that a limit of 8 ug/m³may protect 95% of heathland species (United Kingdom). • Threshold of measurable impact may be lower than 8 ug/m³ for sensitive ecosystems.	
NO_2	• Acidic precipitation	• Almost identical impact to SO_2 and therefore additive.	Botha, 2002.
	• Nitrogen fallout	• Favours species that can exploit nutrient source leading to shifts in species composition	Krupa, 2003.
	Critical Thresholds: • 30 ug/m³ - Annual mean • 75 ug/m³ - 24-hour mean		CLRTAP, 2017.
	• 5 - 10 kg/ha/year (Deposition rate)	• Protects most vulnerable European ecosystems (heaths, bogs, cryptograms)	Krupa, 2003.

Air Quality References Consulted

Blake, L., & Goulding, K. W. T. (2002). Effects of atmospheric deposition, soil pH and acidification on heavy metal contents in soils and vegetation of semi-natural ecosystems at Rothamsted Experimental Station, UK. Plant and soil, 240(2), 235-251.

Botha A. 2002. Specialist study: Air Emission Impacts on Vegetation and Agriculture. In: Environmental Impact Assessment for the proposed Aluminium Pechiney smelter within the Coega Industrial Zone, Port Elizabeth, South Africa. Specialist Studies Report. CSIR Report No. ENV-S-C 2002-092B, Stellenbosch, South Africa.

Chaney, R. L. (1993). Zinc phytotoxicity. In Zinc in soils and plants (pp. 135-150). Springer, Dordrecht.

CLRTAP, 2017. Mapping Critical Levels for Vegetation, Chapter III of Manual on methodologies and criteria for modelling and mapping critical loads and levels and air pollution effects, risks and trends. UNECE Convention on Long-range Transboundary Air Pollution; www.icpmapping.org

Dohmen, G.P.; McNeill, S.; Bell, J.N.B. 1984. Air pollution increases *Aphis fabae* pest potential Nature 307 52-53.

Doley, D. (2006). Airborne particulates and vegetation: Review of physical interactions. *Clean Air and Environmental Quality*, *40*(2), 36.

Dueck, T. A., Van der Eerden, L. J. M., & Berdowski, J. J. M. (1992). Estimation of SO_2 Effect Thresholds for Heathland Species. *Functional Ecology*, 291-296.

Ettler, V. (2016). Soil contamination near non-ferrous metal smelters: A review. *Applied geochemistry*, *64*, 56-74.

Farmer, A. 1993. The effects of dust on vegetation-a review. Environmental Pollution 79 (1993) 63-75.

Flückiger, W., Oertli, J. J., & Flückiger, H. (1979). Relationship between stomatal diffusive resistance and various applied particle sizes on leaf surfaces. *Zeitschrift für Pflanzenphysiologie*, *91*(2), 173-175.

Gheorge, I.F. & Ion, B. 2011. The Effects of Air Pollutants on Vegetation and the Role of Vegetation in Reducing Atmospheric Pollution. Ch 12 In: The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources. Ed (M. Khallaf). Intech Open. ISBN: 978-953-307-528-0.

Herselman, J. E., Steyn, C. E., & Fey, M. V. (2005). Baseline concentration of Cd, Co, Cr, Cu, Pb, Ni and Zn in surface soils of South Africa: research in action. *South African Journal of Science*, *101*(11), 509-512.

Hirano, T., Kiyota, M., & Aiga, I. (1995). Physical effects of dust on leaf physiology of cucumber and kidney bean plants. *Environmental Pollution*, *89*(3), 255-261.

Kabata-Pendias, A., & Pendias, H. (2001). Trace elements in soils and plants CRC Press Inc. *Boca Raton, FL, USA*.

Kapustka, L. A., Lipton, J., Galbraith, H., Cacela, D., & Lejeune, K. (1995). Metal and arsenic impacts to soils, vegetation communities and wildlife habitat in southwest Montana uplands contaminated by smelter emissions: II. Laboratory phytotoxicity studies. Environmental Toxicology and Chemistry: An International Journal, 14(11), 1905-1912.

Kerstiens, G. (1996). Cuticular water permeability and its physiological significance. *Journal of experimental botany*, *47*(12), 1813-1832.

Khan, S.Z., Spreer, W., Pengnian, Y., Zhao, X., Othmanli, H., He. X and J. Müller. 2015. Effect of Dust Deposition on Stomatal Conductance and Leaf Temperature of Cotton in Northwest China. Water 7: 116-131.

Krupa, S. V. (2003). Effects of atmospheric ammonia (NH_3) on terrestrial vegetation: a review. *Environmental pollution*, *124*(2), 179-221.

Manz, M., & Castro, L. J. (1997). The environmental hazard caused by smelter slags from the Sta. Maria de la Paz mining district in Mexico. *Environmental Pollution*, *98*(1), 7-13.

Matsuki, M., Gardener, M.R., Smith, A., Howard, R.K. and A. Gove. 2016. Impacts of dust on plant health, survivorship and plant communities in semi-arid environments. Austral Ecology 41 (4):417-427.

McNeill, S.; Whittaker, J.B.; Watt, (Eds) A.W.; Leather, (Eds) S.R. 1990 Air pollution and tree-dwelling aphids. Population Dynamics of Forest Insects 195-208.

Milton, A., Johnson, M. S., & Cooke, J. A. (2002). Lead within ecosystems on metalliferous mine tailings in Wales and Ireland. *Science of the Total Environment*, *299*(1-3), 177-190.

Naidoo, G., & Chirkoot, D. (2004). The effects of coal dust on photosynthetic performance of the mangrove, Avicennia marina in Richards Bay, South Africa. *Environmental pollution*, *127*(3), 359-366.

Nanos, G. D., & Ilias, I. F. (2007). Effects of inert dust on olive (*Olea europaea* L.) leaf physiological parameters. *Environmental Science and Pollution Research-International*, 14(3), 212-214.

Påhlsson, A. M. B. (1989). Toxicity of heavy metals (Zn, Cu, Cd, Pb) to vascular plants. *Water, Air, and Soil Pollution*, *47*(3-4), 287-319.

Prajapati, S. K., & Tripathi, B. D. (2008). Seasonal variation of leaf dust accumulation and pigment content in plant species exposed to urban particulates pollution. *Journal of environmental quality*, *37*(3), 865-870.

Prajapati, S. K. (2012). Biomonitoring and speciation of road dust for heavy metals using *Calotropis procera* and *Delbergia sissoo*. *Environmental Skeptics and Critics*, *1*(4), 61-64.

Prusty, B.A.K; Mishra P.C. & Azeez P.A. 2005). Dust accumulation and leaf pigment content in vegetation near the national highway at Sambalpur, Orissa, India. Ecotoxicology and Environmental Safety 60(2):228-35.

Reddy, A. M., Kumar, S. G., Jyothsnakumari, G., Thimmanaik, S., & Sudhakar, C. (2005). Lead induced changes in antioxidant metabolism of horsegram (*Macrotyloma uniflorum* (Lam.) Verdc.) and bengalgram (*Cicer arietinum* L.). *Chemosphere*, *60*(1), 97-104.

Saebo, A., Hanslin, H. M., Baraldi, R., Rapparini, F., Gawronska, H., & Gawronski, S. W. (2012, July). Characterization of urban trees and shrubs for particulate deposition, carbon sequestration and BVOC emissions. In *II International Symposium on Woody Ornamentals of the Temperate Zone 990* (pp. 509-517).

Sharifi, M. R., Gibson, A. C., & Rundel, P. W. (1997). Surface dust impacts on gas exchange in Mojave Desert shrubs. *Journal of Applied Ecology*, 837-846.

Sharma, P., & Dubey, R. S. (2005). Lead toxicity in plants. *Brazilian journal of plant physiology*, *17*(1), 35-52.

Seymour, C. L., Milton, S. J., Altwegg, R., Joseph, G. S., & Dean, W. R. J. (2020). Addition of Nitrogen Increases Variability of Vegetation Cover in an Arid System with Unpredictable Rainfall. *Ecosystems*, *23*(1), 175-187.

Squires, V.R. 2016. Dust Particles and Aerosols: Impact on Biota "A Review" (Part II). Journal of Rangeland Science Vol. 6, No. 2: 177-183.

Thompson, J. R., Mueller, P. W., Flückiger, W., & Rutter, A. J. (1984). The effect of dust on photosynthesis and its significance for roadside plants. *Environmental Pollution Series A, Ecological and Biological*, *34*(2), 171-190.

Titshall, L. W., Hughes, J. C., & Bester, H. C. (2013). Characterisation of alkaline tailings from a lead/zinc mine in South Africa and evaluation of their revegetation potential using five indigenous grass species. South African Journal of Plant and Soil, 30(2), 97-105.

Turner, G.F. 2013. Vulnerability of vegetation to mining dust: Jack Hill, Western Australia. MSc thesis, University of Western Australia.

Wood Jr, C. W., & Nash III, T. N. (1976). Copper smelter effluent effects on Sonoran Desert vegetation. *Ecology*, *57*(6), 1311-1316.

World Health Organisation (WHO) (2000). Air Quality Guidelines for Europe. Second Edition.

Zhang, C, *et al*. (2015). Succulent species differ substantially in their tolerance and phytoextraction potential when grown in the presence of Cd, Cr, Mn, Ni, Pb and Zn. Environmental Science and Pollution Research.