Skorpion Zinc Refinery Sulphide Conversion Amendment to EIA Report

Version - Final
25 August 2015

Skorpion Zinc (Pty) Ltd
GCS Project Number: 14-756
Client Reference: Order Number - 4100019309
# Skorpion Zinc Sulphide Conversion

## Report
### Version - Final

![Skorpion Zinc Logo]

### 25 August 2015

Skorpion Zinc (Pty) Ltd

14-756

### DOCUMENT ISSUE STATUS

<table>
<thead>
<tr>
<th>Report Issue</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS Reference Number</td>
<td>14-756</td>
</tr>
<tr>
<td>Client Reference</td>
<td>Order Number - 4100019309</td>
</tr>
<tr>
<td>Title</td>
<td>Skorpion Zinc Refinery Sulphide Conversion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Eloise Carstens</td>
<td>28 July 2015</td>
</tr>
<tr>
<td>Document Reviewer</td>
<td>Andrew Johnstone</td>
<td>28 July 2015</td>
</tr>
<tr>
<td>Director</td>
<td>Andrew Johnstone</td>
<td>28 July 2015</td>
</tr>
</tbody>
</table>

### LEGAL NOTICE

This report or any proportion thereof and any associated documentation remain the property of GCS until the mandator effects payment of all fees and disbursements due to GCS in terms of the GCS Conditions of Contract and Project Acceptance Form. Notwithstanding the aforesaid, any reproduction, duplication, copying, adaptation, editing, change, disclosure, publication, distribution, incorporation, modification, lending, transfer, sending, delivering, serving or broadcasting must be authorised in writing by GCS.
EXECUTIVE SUMMARY

Skorpion Zinc life of mine will end in 2019. This will have an economic impact on both Rosh Pinah and the Namibian economy as a whole. In order to extend the life of the refinery and maintain the design production rate beyond 2019, Skorpion Zinc is planning to treat zinc sulphide concentrates in parallel to the oxide stream from 2017 to 2021. Only thereafter will zinc sulphide be treated, until approximately 2032.

The treatment of zinc sulphide (ZnS) concentrate will require modification to the existing refinery facilities. The modification will involve the construction of a sulphide roaster, acid plant and leaching facilities in order to prepare the sulphide ore for refining in the existing plant. The construction of the new facilities will take place in an area of approximately 200 x 200m east of the existing plant in the Accessory Works Area, which is at present a contractor’s yard.

In order to obtain regulatory approval Skorpion Zinc will have to amend its current EMP to take into consideration the proposed modifications to the existing processing plant and the disposal of additional waste. Specialist studies have been proposed and will be undertaken to ensure that the amendment to the EMP takes into account and mitigates potential environmental impacts associated with the modification.

The construction of the additional processing plant will involve 1000 staff. After the construction phase (and in the operation phase) 24 additional plant operators will be employed in the processing plant. The EMP amendment will consider, amongst other documents, the initial EIA by Walmsely Environmental Consultants (1998), EcoPlan (2000) and the EMP compiled by GCS in 2010. It will also consider the International Finance Corporation (IFC) standards and Vedanta Environmental Management System.

The information provided in this report is in accordance to what is required in the Act and the request for amendment will then be submitted to the Environmental Commissioner.
CONTENTS PAGE

1.1 BACKGROUND .................................................................................................................. 1
1.2 CONDITIONS ON THE CURRENT CLEARANCE CERTIFICATE .................................. 2
1.3 PROJECT LOCATION .......................................................................................................... 2
1.4 RATIONALE .................................................................................................................... 4
2.1 PROJECT OVERVIEW ....................................................................................................... 4
2.2 PROPOSED PLANT MODIFICATIONS: THE SULPHIDE CIRCUIT ...................................... 8
  2.2.1 Bulk handling and storage of Sulphide Zinc concentrate ore .................................... 9
  2.2.2 The construction of a roasting circuit with gas cleaning plant and gas recovery acid
       plant ......................................................................................................................... 9
  2.2.3 The installation and integration of a new calcine leach circuit with the existing
       equipment ................................................................................................................ 10
2.3 WASTE AND BYPRODUCT STREAMS ................................................................................ 12
  2.3.1 Air emissions ........................................................................................................... 12
  2.3.2 Waste and by-products ........................................................................................... 12
  2.3.3 Tailings and Tailings Storage Facility ..................................................................... 14
  2.3.4 Waste Rock Stockpile and TSF Requirements ......................................................... 15
2.4 RESOURCE AND INFRASTRUCTURE REQUIREMENTS .................................................. 16
2.5 POTENTIAL ENVIRONMENTAL IMPACTS ARISING FROM THE PROPOSED PLANT MODIFICATIONS ........................................................ 17
3.1 OVERVIEW ...................................................................................................................... 18
3.2 CLIMATIC CONDITIONS ................................................................................................. 19
  3.2.1 Rainfall and Temperature ......................................................................................... 19
  3.2.2 Wind ......................................................................................................................... 19
  3.2.3 Ambient Air Quality ............................................................................................... 23
3.3 TOPOGRAPHY, GEOLOGY AND SOILS ........................................................................... 23
3.4 GROUNDWATER ............................................................................................................ 25
3.5 SOCIO-ECONOMIC STATUS ........................................................................................... 25
  3.5.1 Karas Region ........................................................................................................... 25
  3.5.2 Rosh Pinah .............................................................................................................. 26
  3.5.3 Skorpion Zinc Mine ................................................................................................. 26
4.1 INTRODUCTION ................................................................................................................. 27
4.2 PUBLIC CONCERNS ........................................................................................................ 30
4.3 PUBLIC FEEDBACK .......................................................................................................... 30
5.1 KEY ENVIRONMENTAL IMPACTS .................................................................................... 31
5.2 METHODOLOGY FOR ASSESSMENT ............................................................................. 31
5.3 IMPACT ON AIR QUALITY, HUMAN AND ANIMAL HEALTH AND VEGETATION ................. 33
  5.3.1 Description .............................................................................................................. 33
  5.3.2 Type of Pollutants ................................................................................................... 34
  5.3.3 Sources of emissions .............................................................................................. 35
  5.3.4 Impacts of particulates and gas emissions on humans, animals and vegetation ........... 39
  5.3.5 Mitigation ................................................................................................................ 39
5.4 IMPACT ON GROUNDWATER AND SOIL ....................................................................... 42
  5.4.1 Description .............................................................................................................. 42
  5.4.2 Acid Generating Potential ...................................................................................... 42
  5.4.3 Neutralization capacity of the limestone with the calcine leach residue ................... 42
  5.4.4 Metals .................................................................................................................... 43
  5.4.6 Limestone ratios .................................................................................................... 44
5.5 IMPACT ON THE SOCIO-ECONOMIC ENVIRONMENT ................................................ 46
  5.5.1 Economic contributions ....................................................................................... 46
  5.5.2 Socio Economic Constraints ................................................................................... 47
  5.5.3 Mitigation ................................................................................................................ 47
6.1 KEY RECOMMENDATIONS .............................................................................................. 51
6.2 CONCLUDING REMARKS ............................................................................................... 51
LIST OF FIGURES

Figure 1-1: Skorpion Zinc Regional Map ................................................................. 3
Figure 2-1: Skorpion Zinc Mine area and Accessory Works Areas .......................... 6
Figure 2-2: Detailed layout plan ............................................................................ 7
Figure 2-3: Process flow - diagram ....................................................................... 8
Figure 2-4: Process within the roasting circuit with gas cleaning plant and gas recovery acid plant .............................................................................................................. 9
Figure 2-5: Integration of a new calcine leach circuit with the existing equipment ....... 11
Figure 3-1: Site Plan ............................................................................................... 18
Figure 3-2: Graph showing the total monthly rainfall and monthly minimum, maximum and average temperatures based on hourly average readings for 2012 for the study region. 19
Figure 3-3: Annual wind rose showing prevailing wind speed and direction for 2012 in the study region (From meteorological station located onsite at Skorpion Zinc). .... 20
Figure 3-4: Season wind rose showing wind direction and wind speed over the study area for the period of 2012 .......................................................................................................................... 21
Figure 3-5: Diurnal wind roses showing prevailing wind speed and direction for 2012 in the study region. ................................................................................................. 22
Figure 3-6: Koivib Mountains to the east of the site ............................................. 24
Figure 5-1: Significance Determination Process ..................................................... 33
Figure 5-2: Results for 2014 from the Dust Monitoring program at Skorpion Zinc .. 38

LIST OF TABLES

Table 2-1: Expected emissions from the proposed modifications to the refinery plant .. 12
Table 2-2: Expected quantities of waste and by products ....................................... 12
Table 2-3: Estimation of how waste product quantities will change throughout the course of the conversion ................................................................. 13
Table 2-4: Composition of ETP cakes ................................................................... 14
Table 2-5: Properties of the oxide tailings .............................................................. 15
Table 2-6: Waste Rock Stockpile and TSF Capacity and Requirements .................. 16
Table 3-1: Identified minerals in the study area ...................................................... 24
Table 3-2: Groundwater quality and characteristics associated with the site .......... 25
Table 4-1: Stakeholder engagement methodology followed .................................. 28
Table 5-1: Impact Assessment Ranking Scale. ....................................................... 32
Table 5-2: Significance Rating Scale. ..................................................................... 33
Table 5-3: Source specifications .......................................................................... 34
Table 5-4: Source emission rates ......................................................................... 35
Table 5-5: Exceedances of international guidelines .............................................. 35
Table 5-6: Summary of the potential impact significance associated with Air pollution. 40
Table 5-7: Acid-base accounting (ABA) results .................................................... 42
Table 5-8: Elements elevated above international guidelines .................................. 43
Table 5-9: Comparison between modelled and measured metal concentrations .... 43
Table 5-10: Summary of the potential significance of groundwater and soil pollution resulting from geochemical waste ......................................................... 45
Table 5-11: Potential CSI Expenditure associated with the proposed conversion ...... 46
Table 5-12: Summary of significance of impacts on the receiving socio-economic environment. 48

LIST OF APPENDICES

APPENDIX A: Minutes of meetings with DEA and community ................................. 50
APPENDIX B: Air Quality Impact Assessment ................................................................. 51
APPENDIX C: Geochemical Waste Classification Study .................................................. 52
APPENDIX D: Attendance list of meetings with DEA and the community ......................... 53
APPENDIX E: Stakeholders List ...................................................................................... 54
APPENDIX F: Background Information Document (BID) .................................................. 55
APPENDIX G: Presentations made during meeting with DEA and Public ......................... 56
APPENDIX H: Email correspondence with I&APs .......................................................... 57
APPENDIX I: Issues and responses Trail ......................................................................... 58
APPENDIX J: Skorpion Zinc Recruitment Policy ............................................................... 59
APPENDIX K: Design of the current waste rock and TSF and proposed extensions of these facilities ......................................................................................................................... 60
APPENDIX L: Skorpion Zinc Refinery Conversion amendment to EMP report .................. 61
1 INTRODUCTION

1.1 Background

Walmsley Environmental Consultants completed an Environmental Impact Assessment (EIA) study for the Skorpion Zinc mine in 1998, defining the sensitive areas on the site and prescribing specific conditions to limit environmental impacts by the mining and refinery operations. The EIA was updated in 2000 by EcoPlan and in 2010 GCS (Pty) Ltd was appointed to compile an Environmental Management Plan (EMP).

In order to extend the life of the refinery and maintain the design production rate beyond 2019, Skorpion Zinc (Pty) Ltd plans to treat zinc sulphide concentrates in parallel to the current oxide stream from 2017 to 2021 and then only treat zinc sulphide concentrate until approximately 2032. The treatment of zinc sulphide (ZnS) concentrate will require modification to the existing refinery facilities. The modification will involve the construction of:

- a sulphide roaster;
- gas cleaning and acid plant; and
- leaching facilities in order to prepare the sulphide ore for refining in the existing plant.

Under Section 39(1) (a) of the Environmental Management Act (No 7 of 2007) the holder of an environmental clearance certificate may request to amend the conditions of the environmental clearance certificate. The request for amendment should be:

a) Made on a form that corresponds with Form 2 of Annexure 1 of the regulations;

b) Accompanied by the fee prescribed in Annexure 2 of the regulations; and

c) Submitted to the Environmental Commissioner.

In order to comply with these requirements, GCS was appointed to obtain regulatory approval to amend Skorpion Zinc’s current Environmental Management Plan (EMP) by taking into consideration the proposed modifications to the existing processing plant and the disposal of additional waste.

After consulting with the Directorate of Environmental Affairs (DEA) on the 1st of December 2014 (See Appendix A), it was concluded that:

- an amendment application should be submitted to the DEA, requesting amendments to the previous Environmental Clearance Certificate;
• specialist studies should be undertaken to ensure that the amendment to the EMP takes into account and mitigates potential environmental impacts associated with the modifications; and

• public consultation should be undertaken with Interested and Affected Parties (I&APs).

This information is provided in this report in accordance to what is required in the Act and the request for amendment will then be submitted to the Environmental Commissioner.

1.2 Conditions on the current clearance certificate

In terms of the relevant legislation, Skorpion Zinc has an approved mining license to operate the mine at Skorpion Zinc. The EIA/EMP is detailed in the document “Skorpion Zinc Environmental Assessment” (Walmsley Environmental Consultants, 1998). The approval of the environmental assessment resulted in a mining license No 108, to be issued in terms of Section 48 (4) of the Minerals Act, 1992.

This document is an application for an amendment to the conditions of the existing EIA report for which Environmental Clearance was granted. It also contains an amended EMP to make provision for the additional activities proposed, i.e. the construction of:

• a sulphide roaster;

• acid plant; and

• leaching facilities in order to prepare the sulphide ore for refining in the existing plant.

1.3 Project Location

Skorpion Zinc is located in the south-western region of Namibia, some 80km north-east of Oranjemund and 20km north-west of Rosh Pinah. The mine and process plants lie inside the eastern boundary of a restricted area, Diamond No. 1, also known as the Sperrgebiet (See Figure 1-1).

The construction of the new facilities will take place in an area of approximately 200m x 200m east of the existing plant in the Accessory Works Area, which is at present a contractor’s yard. The new plant will be constructed as an add-on the existing plant in the Accessory Area (Figure 2-1).
Figure 1-1: Skorpion Zinc Regional Map
1.4 Rationale
The existing oxide resources at the Skorpion Zinc Mine will be depleted by 2019 and despite extensive exploration drilling for additional zinc oxide, no further resources are available in the area. This means that feed for the existing oxide refinery will no longer be available after the Life of mine (LOM).

The availability of zinc sulphide concentrates from Black Mountain and Gamsberg in the Northern Cape, new sulphide deposits in the Rosh Pinah region and the possibility of importing concentrates via the Lüderitz port, resulted in Vedanta approving the construction of a sulphide plant to enable the existing Skorpion Zinc refinery to process zinc sulphide concentrate. Considering the availability of the existing refining infrastructure, an opportunity was identified to not only sustain zinc production but also to increase capacity to 200 Ktpa of Zinc production from the current 150 Ktpa.

The existing Skorpion Zinc plant was constructed to process oxide ore. In order for the plant to process sulphide zinc ore, the plant must be modified to convert the sulphide ore to an oxide ore, which can then be processed in the existing plant. However, by modifying the existing refinery the plant will facilitate the processing of zinc sulphide concentrate along with the oxide ore in the interim (until the LOM, after which zinc sulphide can be treated until approximately 2032).

The proposed conversion holds several socio-economic benefits and will mostly maintain existing employment opportunities, on-the-job training and increase spending power and economic knock-on effects, which will be felt locally in Rosh Pinah. The construction of the additional processing plant will involve 1000 casual construction staff. Only the skilled labour (staff) will be housed on site in a construction camp. After the construction phase is complete, up to 24 plant operators will be permanently employed in the processing plant.

Skorpion Zinc is currently providing approximately 1400 direct employment jobs (800 permanent and 600 contractor employees). With the current LOM and consequently the final closure of the mine set for 2019, the proposed activities would extend the life of the processing plant and in so doing extend the period that positive impacts are incurred.

2 PROJECT DESCRIPTION
2.1 Project Overview
The existing Skorpion refinery circuit was commissioned in early 2003 and was the first ‘mine-to-metal’ operation to commercially apply a purely hydrometallurgical process route (comprising of atmospheric leaching, solvent extraction, electrowinning and final casting of the metal into sizable ingots) to exploit a zinc oxide ore-body. Currently the plant produces 150 000 t/year of Zinc oxide. It is predicted that the oxide ore will be depleted by 2019.
To avoid closure there is an opportunity to treat Zinc Sulphide (ZnS) ore and feed the concentrate into the existing plant a conversion process is required. This implementation will be conducted in two phases:

- Phase 1: Parallel processing of ZnO from the current pit and ZnS (roasting) to produce 200 ktpa of Zn (50 ktpa from oxides and 150 ktpa from sulphide concentrates); and
- Phase 2: Processing of ZnS only through the roaster and the existing plant to produce 150ktpa of Zn.

In order to facilitate the sulphide conversion, the following additions to the current plant will be required:

- Bulk handling and storage of zinc sulphide concentrates;
- The construction of a roasting circuit with gas cleaning plant and gas recovery acid plant; and
- The installation and integration of a new calcine leach circuit.

The new infrastructure will be constructed on the “accessory works area” (Figure 2-1) which is to the east of the current processing plant.

The Ministry of Mines and Energy has approved the additional processing plant as it falls within the definition of “accessory works.” This refers to: “any building, plant or other structure required for purposes of reconnaissance operations, prospecting operations or mining operations or for the disposal of any mineral or group of minerals won or mined in the course of any such operations, or is connected with such operations or disposal, including:

  a) any power plant, transmission line or substation;
  b) any water borehole, well, pipe-line, drilling rig, pump station, tank or dam;
  c) any airfield, helicopter landing-pad, road, gate, rail or railway siding;
  d) any workshop, hangar, store or office;
  e) any explosives magazine;
  f) any sampling plant, processing plant, smelter or refinery whether erected on land or constructed on any vehicle or vessel;
  g) any waste disposal site; or
  h) any camp site or temporary or permanent residential area.”
Figure 2-1: Skorpion Zinc Mine area and Accessory Works Areas
Figure 2-2: Detailed lay out plan

- Plant Upgrade area (Currently used as a lay down area)
- New lay down area
- Construction Camp
- Existing Processing Plant
2.2 Proposed plant modifications: The Sulphide circuit

The sulphide circuit comprises the following major sections (Figure 2-3):

- Concentrate handling system;
- Roaster;
- Waste heat recovery boiler and turbo generator;
- Wet Gas cleaning Plant (WGP);
- Acid Plant; and
- Calcine handling system

![Process flow - diagram](image)

Figure 2-3: Process flow - diagram.
2.2.1 **Bulk handling and storage of Sulphide Zinc concentrate ore**

The concentrate will be transported by road from the Gamsberg mine in South Africa (The transport route will be addressed in another EIA). This EMP amendment is required due to the long lead times and the construction of the acid plant. The Zinc Sulphide (ZnS) Concentrate from Gamsberg (average zinc content of 50%) is received through feed hoppers and conveyed onto storage stockpiles (i.e. different stockpiles for different concentrate feed material). The concentrate is blended using belt feeders and then conveyed to the roaster area for treatment.

2.2.2 **The construction of a roasting circuit with gas cleaning plant and gas recovery acid plant**

The zinc concentrate is fed to a fluid bed roaster (Figure 2-4). Blowers force air into the roaster where it reacts at 950°C with the zinc sulphide to produce a sulphur dioxide off gas and zinc oxide product (calcine). Iron sulphide is converted into a ferrite of zinc that is not easily leached in the mild operating conditions of the Neutral Leach. The calcine is stockpiled before reporting to the Neutral Leach. The calcine requires a calcine handling system for feeding the leaching section. The roaster off gas is treated in an off gas handling facility to reduce the temperature and remove fine dust and fume condensate particles.

A waste heat boiler is used to recover heat from the roaster system, first to generate power and then to provide heating to the combined circuit in the form of medium pressure steam.
Figure 2-4: Process within the roasting circuit with gas cleaning plant and gas recovery acid plant.
The roaster gas is further treated to remove mercury (in order to meet the required chemically pure acid specification) and then dried before reporting to the acid plant where the sulphur dioxide gas is converted into a concentrated sulphuric acid product.

2.2.3 The installation and integration of a new calcine leach circuit with the existing equipment
This circuit involves a soft calcine leach and strong calcine leach residue stage. Most of the zinc oxide in calcine is recovered in the soft calcine leach stage (operating at approximately 60°C) and the target end acidity of the liquor from this section is 5g/l H₂SO₄. Ferric zinc will be leached in the strong calcine leach residue circuit (operating at above 90°C). A zinc rich solution from the sulphide circuit (i.e. overflow after thickening) will combine with the current oxide leach residue slurry in the current oxide neutralisation stage. Iron precipitation will take place in this neutralisation circuit where iron is precipitated as goethite (an iron bearing hydroxide, with the formula FeO(OH)). The combined goethite tailings (neutral leach residue) produced have similar properties to the current oxide tailings. This means that the current tailings conveying and disposal system will be used (Figure 2-5).

Since the calcine leach residue can be effectively neutralized with limestone in a ratio of 1:1, it can therefore be co-disposed with the goethite (neutralization) onto the current unlined TSF.
**Figure 2-5**: Integration of a new calcine leach circuit with the existing equipment.

**Zinc oxide refinery processes**

**Zinc sulphide refinery processes**

**Modification required**

- Fluid bed roaster
- Zinc oxide calcine
- Construction of a roaster, Wet Gas cleaning Plant (WGP), Acid Plant, Concentrate handling system, Calcine handling system

**Neutralization**: Limestone is added to the solution to convert dissolved iron into solid form so that it can be removed by thickening and filtration. Operating conditions: pH of about 4, temperatures of 50°C, Fe, Si and Al are removed in this step.

**Neutralization and iron precipitation**: Zinc rich solution from the sulphide circuit will combine with the current oxide leach residue slurry in the existing oxide neutralization stage. Iron will be precipitated as goethite.

**Tailings disposal**: Solid residue material is conveyed to the residue tailings dump. The plant generates 1.6 and 1.9 million tonnes of tailings per year.

**Tailings disposal**: The addition of 50% ZnS ore will generate approximate 260 000 t of tailings per year. 

**Tailings disposal**: Current tailings conveying and disposal system can be used for the disposal of combined goethite tailings (neutralization residue). Modification might be required for the temporary storage of calcine leach residue.
2.3 Waste and Byproduct streams

2.3.1 Air emissions

Table 2-1 below provides the expected emission rates from the refinery plant:

<table>
<thead>
<tr>
<th>Source description</th>
<th>Run 100 hrs/year</th>
<th>Run 100 hrs/year</th>
<th>Caline handling unit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid plant (new)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roaster plant (start-up)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Heater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcine handling unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Particulate Matter</td>
<td>0</td>
<td>5.4</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>PM$_{10}$ (or factor of TPM)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oxides of Nitrogen (NO$_2$)</td>
<td>0</td>
<td>6.8</td>
<td>7.8</td>
<td>0</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO$_2$)</td>
<td>0</td>
<td>Not available</td>
<td>Not available</td>
<td>0</td>
</tr>
<tr>
<td>Sulphur Dioxide (SO$_2$)</td>
<td>18.24</td>
<td>0.1</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>SO$_3$</td>
<td>&lt;1.25</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other (Please Specify)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

2.3.2 Waste and by-products

The following quantities of waste and by products will be produced by the refinery (Table 2-2Error! Reference source not found.):

<table>
<thead>
<tr>
<th>Waste and by product streams</th>
<th>Quantity</th>
<th>Disposal method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calomel Hg$_2$Cl$_2$</td>
<td>20 tpa</td>
<td>By-product</td>
</tr>
<tr>
<td>Catalyst V$_2$O$_5$</td>
<td>20 kL/year</td>
<td>Waste</td>
</tr>
<tr>
<td>Cu/Cd cake</td>
<td>4 500 tpa</td>
<td>By-product for sale</td>
</tr>
<tr>
<td>Co/Ni cake</td>
<td>100 tpa</td>
<td>By-product for sale</td>
</tr>
<tr>
<td>Waste oil</td>
<td>25 kL/year</td>
<td>Sold to recyclers</td>
</tr>
<tr>
<td>Used oil</td>
<td>25 kL/year</td>
<td>Sold to recyclers</td>
</tr>
</tbody>
</table>

In addition, effluent treatment plant (ETP) cake is also considered to be a waste product of the Refinery Conversion, whilst the Calcine leach residue is considered a potential by-product of the conversion (Table 2-3). The calcine leach could be sold to authorised recyclers since the calcine leach residue can be neutralized with limestone. It could also be disposed of on the current unlined TSF.
Table 2-3: Estimation of how waste product quantities will change throughout the course of the conversion.

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Refinery conversion phase 1 (year 1 and 2)</th>
<th>Refinery conversion phase 2 (year 3 onwards)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETP (t/year)-dry basis</td>
<td>25 000</td>
<td>56 400</td>
<td>42 090</td>
</tr>
<tr>
<td>Neutralization residue (tpa)-dry basis</td>
<td>1 700 000</td>
<td>1 400 000</td>
<td>721 023</td>
</tr>
<tr>
<td>Calcine leach residue-(tpa)-dry basis</td>
<td>-</td>
<td>26 112</td>
<td>24 228</td>
</tr>
<tr>
<td>Total Tailings (t/year)-dry basis</td>
<td>1 725 000</td>
<td>1 482 608</td>
<td>787 412</td>
</tr>
<tr>
<td>Tailings moisture (%)</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>Crud wet (t/year)-wet basis with moisture</td>
<td>60</td>
<td>160</td>
<td>118</td>
</tr>
<tr>
<td>Crud dry (t/year)</td>
<td>-</td>
<td>96</td>
<td>71</td>
</tr>
<tr>
<td>Crud moisture (%)</td>
<td>-</td>
<td>40%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Crud is described as a “heterogeneous, partly inorganic, partly organic mass of material which accumulates predominantly at the interface between organic and aqueous solutions (Gnoinski, 2013). Crud is typically composed of constituents such as Si, Zn, Al, Ni and Cu. The moisture content is anticipated in the range of 40% (Table 2-3). The ratio of crud to tailings is also expected to be small, with maximum 60 tons (wet basis) per year into average tailings of 1800 000 tons per year. Due to the fact that the tailings will decrease once mining stops, crud will be disposed with tailings on the tailings facility.

The ETP Cake is classified as Hazardous Waste according to the waste classification systems (GCS Water and Environmental Consultants (Pty)Ltd, 2009). It will be transported directly from the Skorpion Zinc Mine plant to the tailings dam. The current and expected composition of the ETP cake is summarized in Table 2-4 below:
### Table 2-4: Composition of ETP cakes

<table>
<thead>
<tr>
<th>Time line</th>
<th>Oct-09</th>
<th>Currently (2015)</th>
<th>Refinery Conversion Phase 1</th>
<th>Refinery Conversion Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETP as % of total tails disposed</td>
<td>1.20%</td>
<td>1.4%</td>
<td>3.8%</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

#### COMPOSITION

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>4.80%</td>
<td>0.90%</td>
<td>3.50%</td>
</tr>
<tr>
<td>Pb</td>
<td>not reported</td>
<td>0.054%</td>
<td>0.35%</td>
</tr>
<tr>
<td>Fe</td>
<td>not reported</td>
<td>2.04%</td>
<td>0.30%</td>
</tr>
<tr>
<td>Ni</td>
<td>0.04%</td>
<td>0.005%</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>not reported</td>
<td>0.083%</td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>0.25%</td>
<td>0.006%</td>
<td>0.30%</td>
</tr>
<tr>
<td>Co</td>
<td>0.004%</td>
<td>&lt;0.001%</td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>21%</td>
<td>7.86%</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>not reported</td>
<td>0.48%</td>
<td></td>
</tr>
<tr>
<td>Al</td>
<td>not reported</td>
<td>1.10%</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>not reported</td>
<td>0.45%</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>not reported</td>
<td>0.20%</td>
<td></td>
</tr>
<tr>
<td>SO₄</td>
<td>14%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gypsum</td>
<td>60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>moisture</td>
<td>not reported</td>
<td>37%</td>
<td></td>
</tr>
</tbody>
</table>

2.3.3 **Tailings and Tailings Storage Facility**

Two distinct leaching processes are expected, with the refinery conversion producing two types of tailings namely:

- The neutralization residue (current tailings type) is expected to remain the same and will be disposed onto the current dry, unlined tailings storage facility; and

- The calcine leach residue has a high acid drainage potential but will be neutralised with limestone. Both the precipitate and residual solid waste are then removed by filtration and dewatered on a filter belt. The resulting oxide filter cake is disposed of along with the neutralisation residue on an unlined TSF approximately 2 km north of the mine’s processing plant complex (Phase 1 and 2 of the Refinery Conversion).

The disposal of the tailings will be done according to the Waste Regulations under the Environmental Management Act and in line with the guidelines required by IFC, which is also in line with World Bank Standards.
Table 2-5: Properties of the oxide tailings

<table>
<thead>
<tr>
<th>Elemental Composition</th>
<th>Oxide Tailings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>As, Cd, Cu, Mn, Pb and Zn</td>
<td>These elements are geochemical signatures for sedimentary exhalative zinc mineral deposits, characteristic of the Skorpion Zinc ore deposit and the tailings are significantly enriched in chalcophilic elements, Cd, Cu and Zn, characteristic of sulphide ore deposits.</td>
<td></td>
</tr>
</tbody>
</table>

| Amount of sulphur | 3.4% to 4.1% | The sulphate sulphur constitutions are 100% which indicates complete oxidation of sulphide in tailings. |

| Acidic paste | pH 5.6 - 5.7 | No long term permanent acidity will be generated. |

| Total Dissolved Solids | 2 620 - 3 620 mg/l | The major constituents leached from the tailings include SO₄ (1 810 - 2 590 mg/l), Ca (580 - 670 mg/l), Zn (160 - 590 mg/l), Mg (50 - 280 mg/l), Mn (40 - 100 mg/l) and Na (40 - 90 mg/l). |

<table>
<thead>
<tr>
<th>Trace elements</th>
<th>Al, As, Ba, B, Cd, Co, Cu, Cr, F, Fe, Ni, Sr and V</th>
<th>Chemical composition of Cu-Cd cake</th>
<th>Chemical composition of Ni-Co cake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>14 - 18</td>
<td>5.0 - 10</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>68 - 85</td>
<td>10.0 - 16.0</td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>5.0 - 8.0</td>
<td>1.5 - 2.5</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1.0 - 2.0</td>
<td>Co</td>
<td>4.0 - 7.0</td>
</tr>
<tr>
<td>Ni</td>
<td></td>
<td>Ni</td>
<td>1.0 - 3.0</td>
</tr>
</tbody>
</table>

The current dry unlined tailings disposal facility has been approved under the previous EIA clearance certificate. The neutralization residue associated with the refinery conversion phase 1 and phase 2 can therefore be safely disposed of as part of the current operation onto the unlined tailings dump (GCS Water and Environmental Consultants (Pty)Ltd, 2009). This will be a dry disposal.

2.3.4 Waste Rock Stockpile and TSF Requirements

Table 2-6 below provides a description of the current facilities and the future capacity requirements. The design of the current waste rock and TSF and the proposed extension of these facilities to accommodate future tailings from the Refinery Operations, are illustrated in Appendix K. By extending the current TSF footprint the future requirements will be exceeded.
Table 2-6: Waste Rock Stockpile and TSF Capacity and Requirements.

<table>
<thead>
<tr>
<th>Waste rock stockpile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing waste rock facility capacity</td>
</tr>
<tr>
<td>Waste Rock Requirements</td>
</tr>
<tr>
<td>±55 million tonnes</td>
</tr>
<tr>
<td>120 million tonnes requirement for the next 4 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future requirements</td>
</tr>
<tr>
<td>±31,4 million tonnes of tailings (requirement for 30 years)</td>
</tr>
<tr>
<td>Proposed extended TSF footprint can accommodate estimated 40 million tonnes of tailings - exceeds requirement (potential for optimization of TSF)</td>
</tr>
</tbody>
</table>

| Extension of tailings         |
| To construct the TSF impoundment wall waste rock embankments will be constructed = ±31 million tonnes |

2.4 Resource and Infrastructure requirements

In terms of resources and infrastructure, the following is required (Table 2-7):

Table 2-7: Resource and Infrastructure Requirements

<table>
<thead>
<tr>
<th>Project Phase</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td></td>
</tr>
<tr>
<td>Construction (2015-2017)</td>
<td>• 1000 construction workers</td>
</tr>
<tr>
<td></td>
<td>• Unskilled labour will be sourced locally from Rosh Pinah;</td>
</tr>
<tr>
<td></td>
<td>• Skilled Labour will be housed in a construction camp on site.</td>
</tr>
<tr>
<td></td>
<td>• Skorpion has a labour sourcing policy (Skorpion Zinc (Pty)Ltd, 2015).</td>
</tr>
<tr>
<td>Operational phase</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Approximately up to 24 new permanent plant operators might be employed full time</td>
</tr>
<tr>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 19 m$^3$/t Zn water require and provided by NamWater.</td>
</tr>
<tr>
<td></td>
<td>• 7 800 m$^3$/day currently Mine requirement</td>
</tr>
<tr>
<td>Refinery Conversion</td>
<td></td>
</tr>
<tr>
<td>Phase 1 Oxide &amp; Sulphide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 19.4 m$^3$/t Zn</td>
</tr>
<tr>
<td></td>
<td>• 10 651 m$^3$/day</td>
</tr>
<tr>
<td>Refinery Conversion</td>
<td></td>
</tr>
<tr>
<td>Phase 2 Sulphide only</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 23 m$^3$/t Zn</td>
</tr>
<tr>
<td></td>
<td>• 9 472 m$^3$/day (Less once the mine has closed)</td>
</tr>
<tr>
<td>Power</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Power is supplied from NamPower / Eskom</td>
</tr>
<tr>
<td></td>
<td>• 601 000 megawatt hours /year.</td>
</tr>
<tr>
<td></td>
<td>• The current operating power is 4500-5000 KWh/t Zn. The current operating power is 70-90 MW.</td>
</tr>
<tr>
<td></td>
<td>• A 15% increase is expected when the processes will run parallel during the period 2017 - 2021. After this the power demand will decrease to pre-2017 levels.</td>
</tr>
<tr>
<td>Refinery Conversion Phase 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The Refinery Conversion phase 1 will require 5 644KWh/t Zn.</td>
</tr>
</tbody>
</table>
### Project Phase

<table>
<thead>
<tr>
<th>Project Phase</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refinery Conversion Phase 2 (neutral)</td>
<td>• The Refinery Conversion phase 2 will require 5 550KWh/t Zn.</td>
</tr>
</tbody>
</table>

#### 2.5 Potential environmental impacts arising from the proposed plant modifications

In order for the refinery to process Zn sulphides, modifications to the plant are required. These modifications, as described in this chapter, could result in potential impacts on the receiving environment including:

- Impact on air quality due to the new processing unit;
- Possible impacts on the groundwater and soils resulting from a new residue waste stream as a result of the changed process; and
- Potential socio-economic benefits such as increased employment opportunities, on-the-job training, increased spending power, and economic knock-on effects felt locally in Rosh Pinah.

To better anticipate and predict the potential significance of these impacts, specialists were appointed to further investigate the potential impacts. The studies included:

- Air Emission modellling for the new roaster stack (Appendix B); and
- Waste classifications of the calcine leach residue and the neutralization tailings and disposal requirements (Appendix C).

The following chapter provides the baseline conditions under which the plant modifications will be operated. The potential impacts are then further discussed in Chapter 5.
3 THE RECEIVING ENVIRONMENT

3.1 Overview

The construction of the new infrastructure will be limited to the existing Accessory Work Area (Figure 2-1). This is already a disturbed area, and therefore the impacts associated with the construction are expected to be limited. The key environmental aspects that stand to be affected by the proposed amendment are:

- Air quality;
- Waste Geochemistry;
- Hydrogeology; and
- Socio-economic environment

This chapter provides a brief description of the status quo of these aspects.

Figure 3-1: Site Plan
3.2 Climatic conditions

3.2.1 Rainfall and Temperature
Figure 3-2 indicates that the study area has a low annual rainfall and high annual temperatures. There is also a great amount of seasonal variation in the temperature and the rainfall of the area. The recorded annual rainfall for the site in 2012 was 56mm.

![Graph showing total monthly rainfall and monthly minimum, maximum and average temperatures based on hourly average readings for 2012 for the study region.](image)

Temperatures vary greatly from the summer and winter conditions. The highest temperatures occur during summer with the average temperature being 21.9°C during January 2012. The lowest temperatures occur during winter, with the lowest monthly average temperature of 11.9°C occurring during August 2012. Fog occurs in the project area, and is estimated to occur about 3-5 days per month.

3.2.2 Wind
The entire ecosystem is driven by wind, which redistributes sand, seed, and leaf litter through the ecosystem. The wind in the study area predominantly originates from the southeast (26% of the time), south (16% of the time) and southwest (13% of the time) (Figure 3-3).
Figure 3-3: Annual wind rose showing prevailing wind speed and direction for 2012 in the study region (From meteorological station located onsite at Skorpion Zinc).

Wind speed in the area is mainly slow to moderate. The frequency of high wind velocities, which exceeds 6m/s, is very low and generally originates from the southeast. There is a 31% calm condition in the study area, which dominates the conditions of the study area for 2012. Calm conditions refer in all incidences to a wind speed below 0.75m/s.
Figure 3-4: Season wind rose showing wind direction and wind speed over the study area for the period of 2012.

Figure 3-4 presents the seasonal wind roses for the study area over the period of one year (2012). Autumn, winter and spring experience predominantly southeast winds. Summer winds are usually from the south. The highest wind speeds are experienced in winter. Calm conditions occur 32% during winter. The most of winter is characterised by short-lived, high wind speed events. Summer experiences the lowest wind speeds, with a high frequency of calm conditions in summer.
<table>
<thead>
<tr>
<th>Early Morning: 00:00 – 05:59</th>
<th>Morning: 06:00 – 11:59</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Diurnal Wind Rose" /></td>
<td><img src="image2" alt="Diurnal Wind Rose" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Afternoon: 12:00 – 17:59</th>
<th>Evening / Night: 18:00 – 23:59</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Diurnal Wind Rose" /></td>
<td><img src="image4" alt="Diurnal Wind Rose" /></td>
</tr>
</tbody>
</table>

Figure 3-5: Diurnal wind roses showing prevailing wind speed and direction for 2012 in the study region.

The diurnal wind roses for 2012 are the daily wind over a 24h period. Figure 3-5 shows the direction shift of the wind during the day, which originates from the southeast in the early morning and shifts toward the south. Later in the day, the wind direction can also occur southwest. Figure 3-5 also demonstrates the changes in wind speeds that occur. Wind speed increases throughout the day, with the slowest winds occurring in the early morning periods and the highest speed winds occurring in the afternoon and evening periods. Low calm conditions also occur during the afternoon.
3.2.3 Ambient Air Quality

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

The Skorpion Zinc refinery is located within a very sparsely populated rural area, with the nearest town being Rosh Pinah, approximately 20 km to the southeast of the refinery. Due to the remoteness of the site, no other sources of emissions exist in the area, other than those associated with the refinery. The nearest potential source of atmospheric pollution is associated with C13 road, located approximately 9 km to the southeast of the refinery. This source however is likely to be insignificant as the traffic on this road is infrequent. Therefore, ambient air quality at the site may be regarded as good. However, significant ambient particulate concentrations are anticipated due to the existing mining activities, coupled with high evaporation rates, low precipitation rates, frequent occurrence of high winds and abundance of erodible material.

3.3 Topography, geology and soils

The planned site is located on the south-eastern periphery of the mine site, on a gently sloping plain. The Koivib (Trekpoort) mountains are to the east of the site and rise to 1146m amsl from the surrounding flat plains (Figure 3-6). These mountains trend in a northwesterly direction and the northern foothills form a low natural barrier between the site and the farm Trekpoort.

The mining area is underlain by rock of Precambrian formations known as the Gariep Complex. These formations consist mainly of shale, sandstone and limestone as part of the Schwarzrand Subgroup. They are overlaid by sandstones, black limestone, shale and conglomerates of the Kuibis Subgroup. The sedimentary units overlie the unconformable crystalline and metamorphic rocks of the Vioolsdrif Suite and the Orange River Group. A blanket of unmineralized overburden consisting of calcrete, boulder beds and recent sand dunes overlies the Sedimentary layer.
The distribution of the soils is linked to the topography and wind direction in and around the study area, with a common transition point along the major natural watercourse that runs from the north-west to the south-east. The soils of the area are calcic, typical of arid environments. The soil is shallow and poorly developed with little differentiation between horizons. Organic matter and clay content is low and sodicity and salinity are high. Calcretes and calcritised gravel movement is common in this area. Shallow movement of groundwater is reflected through the occurrence of calcretes and calcritised gravels.

The mineralogy of the area of Skorpion Zinc is shown in Table 3-1 below. The most common minerals are sulphates and silicates.

Table 3-1: Identified minerals in the study area.

<table>
<thead>
<tr>
<th>Mineral</th>
<th><em>Formula</em></th>
<th>Mineral type/group</th>
<th>Sub-group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglesite</td>
<td>PbSO₄</td>
<td>Anhydrous Sulfates</td>
<td>Barite Group</td>
</tr>
<tr>
<td>Bassanite</td>
<td>2CaSO₄·H₂O</td>
<td>Hydrated Sulfates</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>K(Mg,Fe²⁺)(AlSi₃O₁₀)(OH,F)₂</td>
<td>Phyllosilicate 2:1 layer</td>
<td>Mica Group (Bioite subgroup)</td>
</tr>
<tr>
<td>Gypsum</td>
<td>Ca(SO₄)·2H₂O</td>
<td>Hydrated Sulfates</td>
<td>Gypsum</td>
</tr>
<tr>
<td>Microcline</td>
<td>KAlSi₃O₈</td>
<td>Tectosilicate</td>
<td>K(Na,Ba) feldspar subgroup</td>
</tr>
<tr>
<td>Muscovite</td>
<td>KAl₂(AlSi₃O₁₀)(OH,F)₂</td>
<td>Phyllosilicate 2:1 layer</td>
<td>Mica group (Muscovite subgroup)</td>
</tr>
<tr>
<td>Quartz</td>
<td>SiO₂</td>
<td>Tectosilicate</td>
<td>Tectosilicate</td>
</tr>
<tr>
<td>Sphalerite</td>
<td>(Zn,Fe)S</td>
<td>Sulfides</td>
<td>Sphalerite group</td>
</tr>
</tbody>
</table>
3.4 Groundwater

The Zebrafontein Drainage has incised itself along the Zebrafontein Valley Fault, representing a prominent north-east trending lineament. This fault zone plays an important role in the groundwater dynamics of the area as it transects the north-west trending faults (and associated aquifers) over a distance of some 18km. As the Zebrafontein Drainage falls some 500m over this distance, the potential of this fault as a conduit (pipe-like structure or channel that transports water) for down-gradient loss of groundwater is apparent.

Typical groundwater characteristics of the site are provided in Table 3-2.

Table 3-2: Groundwater quality and characteristics associated with the site.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest Water Level</td>
<td>176-187m below surface</td>
</tr>
<tr>
<td>PH</td>
<td>7.7</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>286mS/m</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>1854mg/l</td>
</tr>
<tr>
<td>Sulfates</td>
<td>577mg/l</td>
</tr>
<tr>
<td>Chloride</td>
<td>528mg/l</td>
</tr>
<tr>
<td>Sodium</td>
<td>279mg/l</td>
</tr>
<tr>
<td>Major Ions</td>
<td>Na, Ca, K, Mg, NH₄, Cl, SO₄, NO₃, alkalinity, PO₄ and F</td>
</tr>
</tbody>
</table>
The average size of the households in Karas is 4.2, compared to the national average size of 4.4. As a result of the employment offered by a number of mines in the region and in the fishing and irrigation farming sectors, the largest age group is that between 15 and 59, the working age. This group accounts for almost two-thirds of the population as. About 30% of the population is below the age of 15 and 6% are older than 50. Unemployment levels in the region have increased since the 2001 census, = 29% to a rate of 32% in the 2011 census.

The average household income in Karas is approximately N$21,516.00 pa. This exceeds the national average of N$16,895.00 placing Karas in the mid-range of the human development scale. Agriculture, Forestry and Fishing is the main industry (32.4%) of the work force followed by Mining and Quarrying (8.9%). Wholesale and Retail Trade as well as construction companies each employ about 6 percent of the workforce. The National Household Income and Expenditure Survey of 2009/2010 found that 70.1% of the overall population get their income from wages and salaries, 2.1% from subsistence farming, 2.6% from commercial farming and 11.7% from pensions. Other sources of income included remittances, drought relief and maintenance grants. The majority of those engaged in economic activity in Karas are in wage employment. This means that the labour force is highly vulnerable to non-employment.

3.5.2 Rosh Pinah
The Skorpion Zinc and Rosh Pinah Zinc Corporation (RPZC) jointly developed Rosh Pinah town to house and service mine employees and their families. The two mines formed a joint venture, RoshSkor to administer the joint assets and facilities, undertake service delivery, promote post-mining sustainability and be the driver for the proclamation of the town as a local authority.

The population of the town is currently estimated to be 3 800 people in the formal residential area and 6 000 in the informal area of Tutungeni. The economy of the town is almost entirely based on income from the two mining companies, and exhibits a high degree of dependency. In 2013, Skorpion Zinc had 767 permanent employees and RPZC had 593. Skorpion Zinc contracting and indirect employment caters for another 603 people. In 2012/13, the company paid just under N$157 million in Corporate Social Investments (CSI) within Rosh Pinah and the greater Karas Region. These investments mainly relate to funding for education and healthcare projects as well as subsidies for service delivery for its employees.

3.5.3 Skorpion Zinc Mine
According to the Skorpion Zinc/Vedanta “Report to Society”, in 2012/2013 the mine directly employed 767 staff of which 96% were Namibian. An additional 603 contractors are also indirectly employed. The mine reportedly contributes 2.5% to the Namibian GDP with capital expenditure of N$51 in 2012/2013. It has invested N$4 billion into the Namibian economy over the last five years.
4 PUBLIC CONSULTATION

4.1 Introduction
Public participation forms an important component of an Environmental Impact Assessment (EIA). It provides registered stakeholders with information on the project to continue providing inputs on the project by giving them the opportunity to raise any issues or concerns relevant to the proposed modifications.

Following the instructions of the Directorate of Environmental Affairs (DEA) to engage directly with Interest and Affected Parties (I&APs) in a public consultation process, the following steps (see Table 4-1) were undertaken to notify I&APs:
<table>
<thead>
<tr>
<th>Target group</th>
<th>Consultation tool</th>
<th>Date</th>
<th>Purpose</th>
<th>Recipients/Attendees</th>
<th>Deliverables/Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Environmental Affairs (DEA), Ministry of Environment and Tourism</td>
<td>Meetings</td>
<td>1 December 2014</td>
<td>To inform them of the Conversion project at Skorpion Zinc and to determine the scope of work that need to be done to obtain clearance for this project.</td>
<td>Eleven people attended the meeting (3 from Skorpion Zinc, 2 from GCS and 6 from the DEA)</td>
<td>Attendance list (Appendix D) Presentation (Appendix E) Meeting minutes (Appendix A)</td>
</tr>
<tr>
<td>All immediate neighbouring landowners of Skorpion Zinc Mine for the Skorpion Zinc Refinery Conversion Project, i.e. the immediate neighbouring landowners as well as the chief warden of Karas parks</td>
<td>Background Information Document (BID)</td>
<td>30 March to 1 April 2015</td>
<td>To inform all Stakeholders about the proposed conversion.</td>
<td>All stakeholders</td>
<td>Stakeholders list (Appendix E) BID (Appendix F)</td>
</tr>
<tr>
<td>Stakeholders that were unable to attend the meeting in Rosh Pinah</td>
<td>Email correspondence</td>
<td>23 April 2015</td>
<td>To provide background information and to provide opportunity for these stakeholders to raise their comments or concerns.</td>
<td>Mr Sarel Engelbrecht, Sybie Kotze</td>
<td>Email correspondence (Appendix H) No comments were received from Mr Sarel Engelbrecht, but the lessee of his farm, Mr John Meyer attended the stakeholders meeting.</td>
</tr>
<tr>
<td>Subsequent meetings</td>
<td>14 April 2015 at the offices of Vedanta in Windhoek</td>
<td>To explained the proposed conversion process and to provide opportunity for the stakeholder to raise their comments or concerns.</td>
<td>Mr Andrew Theunissen (attorney and representing Mr Nic Kotze) Carol Steenkamp from GCS, Nora Ndopu of Skorpion Zinc and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target group</td>
<td>Consultation tool</td>
<td>Date</td>
<td>Purpose</td>
<td>Recipients/Attendees</td>
<td>Deliverables/Outcome</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------</td>
<td>------</td>
<td>---------</td>
<td>---------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Herman Fuls who joined via Video Conferencing</td>
<td></td>
</tr>
</tbody>
</table>
4.2 Public Concerns

The Table below provides a summary of the key issues that were raised during the public consultation process. A full description of comments received is provided in the issues and responses trail (Appendix I).

<table>
<thead>
<tr>
<th>Theme</th>
<th>Public concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air emissions</td>
<td>• Gases emitted from the Acid Plant</td>
</tr>
<tr>
<td></td>
<td>• Emissions from the Roaster stack</td>
</tr>
<tr>
<td></td>
<td>• Impact of SO₂ emissions</td>
</tr>
<tr>
<td></td>
<td>• Pb/Ag residue - potential pollution concern</td>
</tr>
<tr>
<td></td>
<td>• Dust (existing problem)</td>
</tr>
<tr>
<td>Ecological</td>
<td>• Settling of dust on vegetation (existing problem)</td>
</tr>
<tr>
<td></td>
<td>• Setting of snares to catch wildlife (existing problem)</td>
</tr>
<tr>
<td>Mining area</td>
<td>• Mining of limestone (on Mr Kotze’s farm)</td>
</tr>
<tr>
<td>Tailings dam</td>
<td>• Proximity to the northern border with the Tsau Khaub (Sperrgebiet) National Park (TKNP) poses both a safety and visual impact</td>
</tr>
<tr>
<td></td>
<td>• Road on the inside of the fence is used as a major patrol road within the Park</td>
</tr>
<tr>
<td></td>
<td>• Need to determine the direction of flow of leakage from the Tailings dam.</td>
</tr>
<tr>
<td>Groundwater</td>
<td>• Potential for groundwater pollution since water table is quite high in the area and the presence of the fresh water spring at Chamise</td>
</tr>
<tr>
<td>Water demand</td>
<td>• Water resources are under pressure due to the number of users that have significantly increased since 1990.</td>
</tr>
<tr>
<td></td>
<td>• Replenishment of groundwater is declining, therefore water supply is a concern.</td>
</tr>
<tr>
<td></td>
<td>• Influence of dewatering of boreholes on ground water levels</td>
</tr>
<tr>
<td>Monitoring</td>
<td>• Existing dust monitoring program needs to be revised</td>
</tr>
<tr>
<td></td>
<td>• Groundwater quality and quantity need to be monitored and the results made known to the stakeholders.</td>
</tr>
</tbody>
</table>

These concerns raised by the stakeholders are further considered in the next chapter of this report.

4.3 Public Feedback

The Environmental Impact Assessment Amendment Report will be circulated for public review:

- A one week comments period will be allowed;
- Comments received on the report will be collated into a Comments and Responses Trail that include statements of how the comments were considered and incorporated into the final Report; and
• After incorporating the comments, the final version will be submitted to the Directorate of Environmental Affairs for an Environmental Clearance Certificate for this project development.

5 ENVIRONMENTAL IMPACT ASSESSMENT

5.1 Key environmental impacts
The construction of the new infrastructure will be limited to the existing Accessory Works Area (Figure 2-1). This is already a disturbed area, and therefore the impacts associated with the construction are expected to be limited. The key environmental aspects that stand to be affected by the proposed amendment are:

• Air quality;
• Waste Geochemistry;
• Hydrogeology; and
• Socio-economic environment

Specialist studies were commissioned to conclusively determine the significance of the potential impacts and identify workable mitigation measures where applicable. The findings of these investigations form the focus of the rest of this chapter. To ensure optimal management of the anticipated impacts specific amendments are consequently made to the EMP.

5.2 Methodology for assessment
Each impact identified was assessed by the specialists in terms of probability (likelihood of occurring), scale (spatial scale), magnitude (severity) and duration (temporal scale). To enable a scientific approach to the determination of the environmental significance (importance), a numerical value is linked to each rating scale. This methodology ensures uniformity and that potential impacts can be addressed in a standard manner so that a wide range of impacts is comparable. The following criteria apply in this impact assessment:

Occurrence
• Probability of occurrence (how likely is it that the impact may occur?); and
• Duration of occurrence (how long may impact last?).

Severity
• Magnitude (severity) of impact (will the impact be of high, moderate or low severity?); and
• Scale/extent of impact (will the impact affect the national, regional or local environment, or only that of the site?).
Status of Impact

- +: Positive impact;
- -: Negative impact; and
- N: Neutral (no impact)

In order to assess each of these factors for each impact, the ranking scales in Table 5-1 were used.

Table 5-1: Impact Assessment Ranking Scale.

<table>
<thead>
<tr>
<th>Probability:=P</th>
<th>Duration:=D</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - Definite/unknown</td>
<td>5 - Permanent</td>
</tr>
<tr>
<td>4 - Highly probable</td>
<td>4 - Long-term (ceases with the operational life)</td>
</tr>
<tr>
<td>3 - Medium probability</td>
<td>3 - Medium-term (5-15 years)</td>
</tr>
<tr>
<td>2 - Low probability</td>
<td>2 - Short-term (0-5 years)</td>
</tr>
<tr>
<td>1 - Improbable</td>
<td>1 - Immediate</td>
</tr>
<tr>
<td>0 - None</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale:=S</th>
<th>Magnitude:=M</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - International</td>
<td>10 - Very high/unknown</td>
</tr>
<tr>
<td>4 - National</td>
<td>8 - High</td>
</tr>
<tr>
<td>3 - Regional</td>
<td>6 - Moderate</td>
</tr>
<tr>
<td>2 - Local</td>
<td>4 - Low</td>
</tr>
<tr>
<td>1 - Site only</td>
<td>2 - Minor</td>
</tr>
<tr>
<td>0 - None</td>
<td></td>
</tr>
</tbody>
</table>

Status of Impact

- +: Positive
- -: Negative
- N: Neutral

Each of the above factors (Table 5-1) were ranked for each impact. The environmental significance of each impact was assessed using the following formula:

\[ SP = (\text{magnitude} + \text{duration} + \text{scale}) \times \text{probability} \]
The maximum value that can be achieved is 100 Significance Points (SP). Environmental effects were rated according to the levels in Table 5-2.

Table 5-2: Significance Rating Scale.

<table>
<thead>
<tr>
<th>SIGNIFICANCE</th>
<th>ENVIRONMENTAL SIGNIFICANCE POINTS</th>
<th>COLOUR CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (positive)</td>
<td>&gt;60</td>
<td>H</td>
</tr>
<tr>
<td>Medium (positive)</td>
<td>30 to 60</td>
<td>M</td>
</tr>
<tr>
<td>Low (positive)</td>
<td>&lt;30</td>
<td>L</td>
</tr>
<tr>
<td>Neutral</td>
<td>0</td>
<td>N</td>
</tr>
<tr>
<td>Low (negative)</td>
<td>&gt;-30</td>
<td>L</td>
</tr>
<tr>
<td>Medium (negative)</td>
<td>-30 to -60</td>
<td>M</td>
</tr>
<tr>
<td>High (negative)</td>
<td>&lt;-60</td>
<td>H</td>
</tr>
</tbody>
</table>

The process detailed in Figure 5-1 was followed in order to determine the significance rating.

---

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

5.3.1 Description

The purpose of the Air Quality Impact Assessment (Simpson, 2015) was to assess the impact of the proposed modifications to the Refinery on the receiving environment. The following key pollutants, and their source, were assessed:

- \( \text{SO}_2 \), associated with the metallurgical acid plant;
- \( \text{NO}_2 \), associated with the roaster plant and pre-Heater; and
• PM$_{10}$, associated with the calcine handling unit, roaster plant and pre-heater.

Wind field conditions in the region predominantly originate from the southeast. Wind speeds are moderate, with a high frequency of winds exceeding 6 m/s, although a high percentage of calm conditions was recorded in 2012 (31%). The Skorpion Zinc refinery is within an uninhabited area, with the nearest town being Rosh Pinah, located approximately 20 km southeast of the refinery. Due to the remoteness of the site, no emission sources exist in the area outside of those associated with the refinery.

5.3.2 Type of Pollutants

Skorpion Zinc Refinery will emit the following pollutants (Table 5-3):

• SO$_2$ is a colourless gas that exhibits a taste and odour at certain levels. SO$_2$ is a precursor to sulphuric acid, an aerosol particulate component that contributes towards acid deposition;

• Particulate matter (PM) is a complex mixture of extremely small particles and liquid droplets. Particles of the pollution can be made up of a great number of components. Dust and soil can contribute greatly to this form of pollution; and

• NO$_2$ is a form of pollution in which is intermediary between the NO (nitric acid) and O$_3$ (ozone). NO$_2$ is a precursor to nitric acid, which is a component of acid deposition.

Table 5-3: Source specifications.

<table>
<thead>
<tr>
<th>Source ID</th>
<th>Existing</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation Time / Annum</td>
<td>365 days / annum</td>
<td>100 hours / annum</td>
</tr>
<tr>
<td>Stack Height (m)</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Stack Diameter (m)</td>
<td>0.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Dry Gas Velocity (m/s)</td>
<td>8.78</td>
<td>7.6</td>
</tr>
<tr>
<td>Volume Flux (m$^3$/s)</td>
<td>2.1</td>
<td>20</td>
</tr>
<tr>
<td>Gas Temperature (°C)</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>X Coordinates (m)</td>
<td>659181.701 E</td>
<td>659261.504 E</td>
</tr>
<tr>
<td>Y Coordinates (m)</td>
<td>6921261.795 N</td>
<td>6921139.684 N</td>
</tr>
</tbody>
</table>
5.3.3 Sources of emissions

Findings from the emissions quantification and dispersion modelling indicated the following pollutants and their sources of emission (Table 5-4):

Table 5-4: Source emission rates

<table>
<thead>
<tr>
<th>Source ID</th>
<th>Emission Source</th>
<th>Existing (g/s)</th>
<th>Proposed (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>New acid plant is metallurgical acid plant (acid from roaster off gas) not sulphur burning. Vehicular emissions which contributes in lesser concentrations. Combustion of coal during industrial processes.</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>NOₓ</td>
<td>NO₂ is a secondary pollutant that originates from the burning of fossil fuel to produce NO, the source is than followed with a high level exposure to Ultraviolet radiation to produce NO₂.</td>
<td>-</td>
<td>6.8</td>
</tr>
<tr>
<td>NO₂ (75% of NOₓ)</td>
<td>-Particular matter is emitted from the surrounding area of chemicals, metals, dust etc. The formation of particulate matter is determined by the conditions of the surrounding area.</td>
<td>0.2</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Predicted ambient concentrations were assessed against the International Finance Corporation (IFC) ambient air quality guidelines. Where necessary (due to a lack of IFC or WHO guidelines), comparison is made to the South African National Ambient Air Quality Standards (Table 5-5).

Table 5-5: Exceedances of international guidelines.

<table>
<thead>
<tr>
<th></th>
<th>Exceedances of guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>• Full compliance with the South African annual SO₂ NAAQS is predicted for all stack heights, at all receptors, with concentrations remaining low</td>
</tr>
<tr>
<td></td>
<td>• Should the stack height be increased from 50 m to 100 m, an improvement in annual average concentrations at discrete receptors of 59% is predicted, whilst there is a 32%</td>
</tr>
<tr>
<td>Exceedances of guidelines</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>improvement in this average achieved by extending the stack from 50 m to 70 m; and • Annual average plume maps indicate emissions associated with the new acid plant will predominantly disperse towards the northwest, which correlates to the predominant winds, which originate from the southeast; also illustrating that emissions from the acid plant are highly unlikely to impact on the nearest town (Rosh Pinah) • Exceedances of the 24-hour IFC guideline are predicted at receptor R_NW1 at a stack height of 50 m for the new acid plant. However, when the stack height is increased to 70 m or 100 m, no exceedances are predicted at this receptor;</td>
<td></td>
</tr>
<tr>
<td>NO$_2$ (75% of NO$_x$)</td>
<td></td>
</tr>
<tr>
<td>• P100 (particle size of 100 microns) hourly concentrations are predicted to exceed the IFC guideline; • However, the probability of these exceedances occurring are low considering the roaster plant and pre-heater only operate 100 hours per annum, while their predicted hourly concentrations are calculated using 8784 hours (number of hours in 2012); • The plume map indicates highest concentrations will disperse towards the northwest, correlating to the predominantly southeast winds, although low levels of dispersion also occur towards the northeast, southwest and southeast, as was evident in the short-term SO$_2$ dispersion patterns; and • The predicted exceedance isopleths indicate that should exceedances occur, considering the operational hours per annum, then these will predominantly occur within the fenceline of Skorpion Zinc, with little or no impact on the receiving environment.</td>
<td></td>
</tr>
<tr>
<td>PM (Modelled as PM$_{10}$)</td>
<td></td>
</tr>
<tr>
<td>• P100 24 hour concentrations are predicted to remain well below the IFC 24 hour guideline with no exceedances predicted within the modelling domain; • The plume map indicates highest concentrations will disperse towards the northwest and east-northeast, although low levels of dispersion also occur towards the southwest and southeast, as was evident in the short-term SO$_2$ dispersion patterns.</td>
<td></td>
</tr>
<tr>
<td>Exceedances of guidelines</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Existing fugitive dust (particles carried into the air either by man-made or natural activities in open areas. Composed mainly of soil particles) emissions</strong></td>
<td></td>
</tr>
<tr>
<td>• The dust emission impact is expected to be less for both mining and tails as a result of the refinery conversion.</td>
<td></td>
</tr>
<tr>
<td>• Although the cast house capacity will be increased from 150 to 200ktpa Zn, the bag house capacity will be upgraded for extra capacity to ensure dust control.</td>
<td></td>
</tr>
<tr>
<td>• Skorpion Zinc runs a dust management program, which includes a network of dust fallout samplers. The methodology and standard used during program are provided in the Air Quality Impact Assessment report for Skorpion Zinc Refinery Conversion.</td>
<td></td>
</tr>
</tbody>
</table>
Figure 5-2: Results for 2014 from the Dust Monitoring program at Skorpion Zinc.
5.3.4 *Impacts of particulates and gas emissions on humans, animals and vegetation*

The health effect of an emitted source is dependent on the concentration of the emission (Simpson, 2015).

- **SO₂** has the greatest effect in high concentrations. Health effects include breathing difficulties, weakening pulmonary defenses and aggravation of cardiovascular disease.

- Health effects from Particulate Matter with less than 10 Microns can penetrate deep into lungs. Smaller particles with an aerodynamic diameter of less than 2.5 microns can enter the bloodstream via capillaries in the lungs. These sources have the potential to be laid down in the bloodstream and capillaries of the lungs as plaques. Health effects include respiratory problems, lung tissue damage, cardiovascular problems, cancer and premature death. Acidic particles may damage buildings, vegetation and acidify water sources.

- **NO₂** irritates the lungs and can lead to lower resistance to respiratory infections.

5.3.5 *Mitigation*

- To ensure minimal ground level SO₂ concentrations, the stack should be built to a height of at least 70m (not 50m). Whilst a stack height of 100 m is ideal for dispersion, a 70m stack height is considered the best practicable option given that at 70m, impacts are confined within the plant boundary and there are no significantly affected off-site receptors.

- Options for limiting the entrainment of surface dust include (See EMP):

  - Removal of dust from surfaces;
  - Increasing surface roughness;
  - Obstructing wind flow;
  - Wetting the dust source; and
  - Chemically coating the dust source

Table 5-6 below provides a summary of the Impact Assessment for Air Pollution.
Table 5-6: Summary of the potential impact significance associated with Air pollution.

<table>
<thead>
<tr>
<th>Environmental Parameter</th>
<th>Impact source</th>
<th>Pre/post mitigation</th>
<th>P</th>
<th>D</th>
<th>S</th>
<th>M</th>
<th>SP</th>
<th>Management Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air quality</td>
<td>SO₂</td>
<td>Pre-mitigation</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>-30 M</td>
<td>• To reduce ground-level SO₂ concentrations, the stack should be constructed at a minimum height of 70 m as the best practicable environmental option.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-mitigation</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>-14 L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO₂</td>
<td>Pre-mitigation</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>-5 L</td>
<td>• Should exceedances occur, considering the operational hours per annum, these will predominantly occur within the fenceline of Skorpion Zinc, with little or no impact on the receiving environment. Therefore no management measures are required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-mitigation</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PM₁₀</td>
<td>Pre-mitigation</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0 N</td>
<td>• PM₁₀ concentrations remain low throughout the modelling domain, with no exceedances of the IFC guideline predicted. Therefore no management measures are required.</td>
</tr>
<tr>
<td>Environmental Parameter</td>
<td>Impact source</td>
<td>Pre/post mitigation</td>
<td>P</td>
<td>D</td>
<td>S</td>
<td>M</td>
<td>SP</td>
<td>Management Measures</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------</td>
<td>---------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>----</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-mitigation</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing dust</td>
<td></td>
<td>Pre-mitigation</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>-60 M</td>
<td>• Appendix C in the EMP indicates the dust control measures that will be implemented.</td>
</tr>
<tr>
<td>(Plant modifications will not produce dust)</td>
<td></td>
<td>Post-mitigation</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>-10 L</td>
<td>• The dust monitoring programme in the EMP will be adhered to.</td>
</tr>
</tbody>
</table>
5.4 Impact on groundwater and soil

The waste characterisation of residues from the proposed new zinc sulphide plant of Skorpion Zinc (Pty) Ltd was conducted by Geostratum (2015) (attached to this EIA Report as Appendix C).

5.4.1 Description

During the 1998 EIA it was concluded that the oxidised secondary zinc deposit contained no sulphide minerals that could contribute to groundwater pollution. This meant that neither the pit, nor the waste rock dumps would be acid generating. However, with the proposed modifications to the plant an updated waste characterization study was required to determine the net acid generating potential of the materials as well as any potential metals that could be contained in the residues.

5.4.2 Acid Generating Potential

According to Geostratum (2015) the samples could primarily be classified as non-acid forming. Only the sample from the calcine leach residue showed a higher acid potential than neutralisation potential. It is therefore only residues from the calcine leach sample that would have the potential to generate acid mine drainage. The limestone sample indicated a low %S and very high neutralisation potential and therefore has a significant potential to neutralise acidity (Table 5-7).

### Table 5-7: Acid-base accounting (ABA) results

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Paste pH</th>
<th>Sulphide %S</th>
<th>Total %S</th>
<th>AP CaCO$_3$ kg/t</th>
<th>NP CaCO$_3$ kg/t</th>
<th>NNP CaCO$_3$ kg/t</th>
<th>NP/AP</th>
<th>Rock Type</th>
<th>Rock Type %S</th>
<th>Rock Type NP/AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNZ 451</td>
<td>5.51</td>
<td>2.35</td>
<td>5.80</td>
<td>73.40</td>
<td>105.15</td>
<td>31.75</td>
<td>1.43</td>
<td>IV</td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>BNZ 452</td>
<td>2.63</td>
<td>9.05</td>
<td>14.43</td>
<td>282.80</td>
<td>92.64</td>
<td>-190.16</td>
<td>0.33</td>
<td>I</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>BNZ 454</td>
<td>5.05</td>
<td>1.96</td>
<td>10.52</td>
<td>61.39</td>
<td>97.41</td>
<td>36.02</td>
<td>1.59</td>
<td>IV</td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>BPZ 455</td>
<td>8.83</td>
<td>0.22</td>
<td>0.38</td>
<td>6.97</td>
<td>570.75</td>
<td>563.78</td>
<td>81.86</td>
<td>IV</td>
<td>I</td>
<td>IV</td>
</tr>
<tr>
<td>BPZ 456</td>
<td>5.96</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

BNZ451 - “neutralisation solid” - Mix of calcine and Skorpion standard feed material in neutralisation.
BNZ452 - “leaching solid” - From strong calcine leach residue
BNZ454 - “neutralisation solid” - From calcines only
BPZ 455 - Limestone
BPZ 456 - Calcine leach residue/limestone mixed sample

5.4.3 Neutralization capacity of the limestone with the calcine leach residue

During the assessment (Geostratum, 2015) it was determined that the pH of the calcine leach residue was acidic (-pH 2.5-3). After mixing the calcine leach residue with limestone at a 1:3 weight ratio (i.e. ratio limestone: calcine leach residue) a near-neutral leachate was obtained with a pH 6.82;
5.4.4 Metals

Metals that were extracted included As, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, W, and Zn. Elements elevated above the EHS and WHO guidelines are illustrated in Table 5-8:

Table 5-8: Elements elevated above international guidelines.

<table>
<thead>
<tr>
<th></th>
<th>IFC</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutralization residue</td>
<td>Cd, Cu and Zn,</td>
<td>Cl</td>
</tr>
<tr>
<td>(Sample BNZ 451):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcine leach residue</td>
<td>Cd, Cu, Fe and Zn</td>
<td>Cl, Cr and Ni</td>
</tr>
<tr>
<td>(Sample BNZ 452):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutralization residue</td>
<td>Cd, Cu and Zn</td>
<td>Cl</td>
</tr>
<tr>
<td>Sample (BNZ 454)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limestone (Sample BPZ</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>455)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limestone/calcine leach</td>
<td>Cd, Pb and Zn</td>
<td>Cl and Ni</td>
</tr>
<tr>
<td>residue mix (Sample BPZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>456)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.4.5 Metal concentrations in leachate upon neutralization of the calcine leach residue;

The mixing of limestone with the calcine leach residue sample significantly reduced the metals elevated in the leachate. The concentration of Cu, Al, Fe and Mn decreased to below detection level and the concentration of Pb and Zn decreased significantly (see Table 5-9). Cu, Pb and Zn showed a significant decrease in concentration at pH 7 and more so at pH 7.6. Cd and Ni were present as more persistent contaminants in the leachate. A limestone blend ratio of 1:1 (1 part limestone to neutralise 1 part calcine leach residue dry basis) would eliminate any potential contamination impact. It is therefore recommended to neutralise the calcine leach residue with limestone (1:1 ratio) before safe co-disposal onto the current unlined tailings facility. To ensure the stability of this blend, a continued geochemical testing will be done.

Table 5-9: Comparison between modelled and measured metal concentrations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Modelled concentrations</th>
<th>Leachate test results calcine leach + limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>pH 3 increasing to pH 7</td>
<td>pH 7 increasing to 7.6</td>
</tr>
<tr>
<td>Cu</td>
<td>4.71 - 0.06 (pH 7.2)</td>
<td>0.06 - &lt;0.02</td>
</tr>
<tr>
<td>Pb</td>
<td>2.38 - 0.8</td>
<td>0.8 - 0.06</td>
</tr>
<tr>
<td>Zn</td>
<td>64 - 34 (pH 7.2)</td>
<td>34 - 3.35</td>
</tr>
<tr>
<td>Ni</td>
<td>0.182</td>
<td>0.182</td>
</tr>
<tr>
<td>Cd</td>
<td>0.651</td>
<td>0.651 - 0.367</td>
</tr>
<tr>
<td>Al</td>
<td>4.986 - &lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Fe</td>
<td>28.7 - &lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Mn</td>
<td>3.64 - &lt;0.1</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>
5.4.6 Limestone ratios

Based on the ABA results it was calculated that 1 part limestone should be used to neutralise 3 parts calcine leach residue. This yielded a paste pH of almost 6 and a leachate pH of 6.82. This is adequate to neutralise the calcine leach residue.

In order to reduce the metal concentrations in seepage from the calcine leach residue a pH of at least 7.6 should be obtained. To increase the pH from 6.8 to 7.6 would require a 50% increase in limestone. That means that 1 part limestone should be used to neutralize 2 parts of calcine leach residue. To reduce the Cu, Pb and Zn concentrations conditions should be favourable for carbonate minerals of these metals to precipitate.

5.4.7 Mitigation

- If limestone is added to the calcine leach in a ratio of 1:3 (i.e. calcine leach : limestone) a near-neutral leachate was obtained with a pH 6.82;

- If limestone is added to the calcine leach in a ratio of 1:2 (i.e. calcine leach : limestone) concentrations of Cu, Al, Cu, Fe and Mn will be decreased to below detection level and the concentration of Pb and Zn decreased significantly. Cd and Ni were present as more persistent contaminants in the leachate. Due to the latter statement, a limestone blend ratio of 1:1 (1 part limestone to neutralise 1 part calcine leach residue dry basis) would minimize any potential contamination impact. It is therefore recommended to neutralise the calcine leach residue with limestone (1:1 ratio) before safe co-disposal onto the current unlined tailings facility.

- However a weight ratio of 1:1 limestone to calcine leach residue would declassify the leach as a hazardous waste and it can therefore be disposed of with other residues on the existing tailings facility. Continued geochemical testing would be required to ensure that the blend is stable.

Table 5-10 below provides a summary of the Impact Assessment for Groundwater and soil pollution resulting from geochemical waste.
Table 5-10: Summary of the potential significance of groundwater and soil pollution resulting from geochemical waste.

<table>
<thead>
<tr>
<th>Environmental Parameter</th>
<th>Impact source</th>
<th>Pre/post mitigation</th>
<th>P</th>
<th>D</th>
<th>S</th>
<th>M</th>
<th>SP</th>
<th>Management Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Groundwater and soils   | Calcine leach residue  | Pre-mitigation      | 4 | 5 | 3 | 8 | -64 H | • By neutralizing the calcine leach residue with limestone in a ratio of 1:3 the leach can be declassified as hazardous waste and can therefore be disposed on the existing tailings dam.  
• The tailings facility should be lined if neutralisation with limestone at 1:2 is not done. |
|                         |                        | Post-mitigation     | 2 | 1 | 0 | 2 | -6 L |                     |
|                         | Metals                 | Pre-mitigation      | 4 | 5 | 3 | 8 | -64 H | • To reduce the metal concentrations in seepage from the calcine leach residue a pH of at least 7.6 should be obtained by neutralizing the calcine leach residue with limestone in a ratio of 1:1. |
|                         |                        | Post-mitigation     | 2 | 1 | 0 | 2 | -6 L |                     |
5.5 Impact on the socio-economic environment

The closure of the mine will negatively affect the local community and the Namibian economy as a whole. By extending the life of the existing processing plant through the proposed modifications to process ZnS Ore, the proposed conversion could have significant socio-economic benefits including increased employment opportunities, on-the-job training, increased spending power, and economic knock-on effects felt locally in Rosh Pinah. The proposed activities would extend the life of the processing plant and in so doing extend the period that positive impacts are felt.

Because the site is already established (i.e. existing infrastructure), the possible negative effects typically associated with the construction of a mine will be avoided or minimized and thus the status quo will remain:

- the existing infrastructure (including housing, services, sewerage system and road infrastructure) of the mine can be taken over;
- no change to the current visual impact is expected due to the modifications to the plant;
- the impacts associated air emissions are expected to be less than what it currently is (see Section 5.3); and
- there will be no change in land use and potential nuisance activities to surrounding neighbors will be the same or less.

5.5.1 Economic contributions

The proposed project will contribute to the national economy through direct and indirect job creation and a number of spin-off effects likely to cause an economic boost to the local and regional economy. Sustainable income for all those employed at the mine and within the residing area will allow for increases in economic prosperity, spending patterns and aid in financial resilience. Based on the information provided in Table 5-12, employees are likely to spend a large portion of their salaries on goods and services in town (Table 5-11). In turn, additional spending will add to the income of others bringing with it the potential for job creation.

Table 5-11: Potential CSI Expenditure associated with the proposed conversion.

<table>
<thead>
<tr>
<th>Breakdown</th>
<th>N$ M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosh Pinah &amp; //Karas Region</td>
<td>157</td>
</tr>
<tr>
<td>Namibia</td>
<td>981</td>
</tr>
<tr>
<td>Taxes and Royalties</td>
<td>79</td>
</tr>
</tbody>
</table>
5.5.2 Socio Economic Constraints

The influx of unskilled job seekers into Rosh Pinah as soon as project construction/commencement is announced is a potential concern since it could add to the current unemployment rate and further contribute to existing social ills.

Hazardous substances and wastes in water, air, and soil can have serious, negative impacts on public health. The term ‘hazardous substances’ is broad and includes all substances that can be harmful to people and/or the environment. Because of the quantity, concentration, or physical, chemical or infectious characteristics, hazardous substances may:

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

5.5.3 Mitigation

- Having a labour agent or recruitment station based in Tutungeni/Rosh town will help resolve the issue of influx. This will allow for a more controlled process where workers are sourced through an agent as required by Skorpion Zinc.
- The internal policy developed by Skorpion Zinc for the recruitment of workforce for the project should be implemented (See Appendix J)
- Recommendations regarding potential air emissions and waste should be followed as described in the previous sections.

Table 5-12 below provides a summary of the Socio-economic Impact Assessment.
Table 5-12: Summary of significance of impacts on the receiving socio-economic environment.

<table>
<thead>
<tr>
<th>Environmental Parameter</th>
<th>Impact</th>
<th>Pre/post mitigation</th>
<th>P</th>
<th>D</th>
<th>S</th>
<th>M</th>
<th>SP</th>
<th>Management Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-economic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contribution to the Namibian economy through capital expenditure</td>
<td>Pre-mitigation</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>-68 H</td>
<td>-The proposed modification to the refinery will extend the life of the existing processing plant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-mitigation</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>+68 H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary economic boost</td>
<td>Pre-mitigation</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>8</td>
<td>-64 H</td>
<td>-Locals First Policy, employ local contractors not foreigners. Encourage local spending.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-mitigation</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>+44 M</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Job creation</td>
<td>Pre-mitigation</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>-64 H</td>
<td>-The proposed modification to the refinery will extend the life of the existing processing plant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-mitigation</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>+64 H</td>
<td></td>
</tr>
<tr>
<td>Environmental Parameter</td>
<td>Impact</td>
<td>Pre/post mitigation</td>
<td>P</td>
<td>D</td>
<td>S</td>
<td>M</td>
<td>SP</td>
<td>Management Measures</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------</td>
<td>---------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>----</td>
<td>---------------------</td>
</tr>
</tbody>
</table>
|                         | Influx of job Seekers and Employed adding to existing pressures | Pre-mitigation | 4 | 4 | 3 | 6 | -52M | • Having a labour agent based in Tutungeni / Rosh Pinah town will help resolve the issue of influx. This will allow for a more controlled process where workers are sourced through an agent as required by Skorpion Zinc.  
• The internal policy developed by Skorpion Zinc for the recruitment of workforce for the project should be implemented (See Appendix J) |
|                         | Post-mitigation | 3 | 2 | 3 | 4 | -27L | |
|                         | Public Health | Pre-mitigation | 4 | 4 | 3 | 8 | -63H | • Implement recommendations made in previous sections of the report to avoid or limit the effect of air emissions and groundwater and soil contamination. |
|                         | Post-mitigation | 2 | 2 | 0 | 2 | -7 L | |
6 CONCLUSION AND RECOMMENDATIONS

The key ecological and social impacts related to the proposed construction and operation of the proposed mine can be summarised as follows:

- **Impact on Air Quality**: Dispersion modelling results indicated some exceedances of NO$_2$, and SO$_2$ on the mine site. With NO$_2$ emissions the probability of these exceedances occurring are low considering the roaster plant and pre-heater only operate 100 hours per annum. Should exceedances occur then these will predominantly occur within the fenceline of Skorpion Zinc, with little or no impact on the receiving environment. Since the new acid plant is a metallurgical acid plant (acid from roaster off gas) and not sulphur burning, the main sources of SO$_2$ is from vehicular emissions and the combustion of coal during industrial processes. Annual average plume maps indicate emissions associated with the new acid plant will predominantly disperse towards the northwest, illustrating that emissions from the acid plant are highly unlikely to impact on Rosh Pinah. To reduce ground-level SO$_2$ concentrations, the stack should be constructed at a minimum height of 70 m. The study found no exceedances of PM$_{10}$ levels. Dust is an existing problem associated with the mining operations. To address the problem specific mitigation measures are prescribed in the EMP.

- **Impact on groundwater and soil**: Residues from the calcine leach residue sample indicated a high acid potential that would have the potential to generate acid mine drainage. By neutralizing the calcine leach residue with limestone in a ratio of 1:3 the leach can be declassified as hazardous waste and can therefore be disposed of on the existing tailings dam. The samples also contained As, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, W, and Zn. To reduce the metal concentrations in seepage from the calcine leach residue a pH of at least 7.6 should be obtained by neutralizing the calcine leach residue with limestone in a ratio of 1:2. Even upon neutralisation to pH 7.6 Cd and Ni will still be present as persistent contaminants. In order to reduce the risk of these contaminants Skorpion Zinc is committed to a 1:1 neutralisation ratio with continued geochemical testing to ensure that the blend is stable. The general impact of the mine is seen to be of low significance if the recommended mitigation measures are implemented.
• **Impact of the project on the socio-economic environment:** The project is expected to make several positive contributions the local economy of Rosh Pinah, the Karas Region and Namibia and cumulatively, will contribute to Namibia reaching its Vision 2030 goals. However, some negative impacts such as the expected influx of people to town are anticipated. Nevertheless, it is concluded that the positive impacts resulting from this proposed project will outweigh the negative ones.

6.1 **Key Recommendations**

The following key recommendations are made in respect to the proposed project:

- To ensure minimal ground level SO\(_2\) concentrations, the stack should be built to a height of at least 70 m (not 50 m). At this height, impacts are already confined within the plant boundary and there are no significantly affected off-site receptors;

- To curb the existing problem with dust the options for limiting the entrainment of surface dust should be implemented as prescribed in Appendix C of the EMP;

- To reduce the metal concentrations in seepage from the calcine leach residue a pH of at least 7.6 should be obtained. In order to achieve this, a weight ratio of 1:1 limestone to calcine leach residue should be achieved with continued geochemical testing to ensure that the blend is stable. In achieving this weight ratio the leach can be declassified as hazardous waste and can therefore be disposed of on the existing tailings dam and

- Having a labour agent / recruitment based in Tutungeni/Rosh Pinah town will help resolve the issue of influx. This will allow for a more controlled process where workers are sourced through an agent as required by Skorpion Zinc. In addition, the internal policy developed by Skorpion Zinc for the recruitment of workforce for the project should be implemented.

6.2 **Concluding Remarks**

The requirements provided in the 2002 EMP still apply. The Environmental Management Plan (EMP) (see Appendix L) has been updated to incorporate the modifications to the Refinery plant and should be implemented as recommended in the EIA. Based on the information provided in this Report, GCS is confident that the modification proposed to the existing refinery plant would not cause adverse effects to the receiving environment other than what was proposed in the 2002 EIA. If the recommendations provided in the EMP (see attached) are implemented, the conditions of the Environmental Clearance Certificate would remain and it is therefore requested that Environmental Clearance is granted for the amendments, and that the current Certificate is renewed.
7 BIBLIOGRAPHY


APPENDIX A: Minutes of meetings with DEA and community
APPENDIX B: *Air Quality Impact Assessment*
APPENDIX C: Geochemical Waste Classification Study
APPENDIX D: Attendance list of meetings with DEA and the community
APPENDIX E: Stakeholders List
APPENDIX F: *Background Information Document (BID)*
APPENDIX G: Presentations made during meeting with DEA and Public
APPENDIX H: *Email correspondence with I&APs*
APPENDIX I: Issues and responses Trail
APPENDIX J: *Skorpion Zinc Recruitment Policy*
APPENDIX K: Design of the current waste rock and TSF and proposed extensions of these facilities
APPENDIX L: *Skorpion Zinc Refinery Conversion amendment to EMP report*
Skorpion Zinc Sulphide Refinery Conversion
Amendment to EMP

Report

Version - 1
25 August 2015

Skorpion Zinc (Pty) Ltd
GCS Project Number: 14-756
Client Reference: Order Number - 4100019309
25 August 2015

Skorpion Zinc (Pty) Ltd

14-756

DOCUMENT ISSUE STATUS

<table>
<thead>
<tr>
<th>Report Issue</th>
<th>Draft</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS Reference Number</td>
<td>GCS Ref - 14-756</td>
</tr>
<tr>
<td>Client Reference</td>
<td>Order Number - 4100019309</td>
</tr>
<tr>
<td>Title</td>
<td>Skorpion Zinc Sulphide Refinery Conversion Amendment to EMP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Eloise Carstens</td>
<td>28 July 2015</td>
</tr>
<tr>
<td>Document Reviewer</td>
<td>Jacques Harris</td>
<td>28 July 2015</td>
</tr>
<tr>
<td>Director</td>
<td>Andrew Johnstone</td>
<td>28 July 2015</td>
</tr>
</tbody>
</table>

LEGAL NOTICE

This report or any proportion thereof and any associated documentation remain the property of GCS until the mandator effects payment of all fees and disbursements due to GCS in terms of the GCS Conditions of Contract and Project Acceptance Form. Notwithstanding the aforesaid, any reproduction, duplication, copying, adaptation, editing, change, disclosure, publication, distribution, incorporation, modification, lending, transfer, sending, delivering, serving or broadcasting must be authorised in writing by GCS.
EXECUTIVE SUMMARY

Skorpion Zinc is located in the south-western region of Namibia, some 80km north-east of Oranjemund and 20km north-west of Rosh Pinah. The mine and process plants lie just inside the eastern boundary of a restricted area, Diamond No. 1, also known as the Sperrgebiet.

An environmental assessment to World Bank standards was undertaken by Walmsley Environmental Consultants (Pty) Ltd during the project feasibility stage in 1998 and an addendum to this original assessment was produced by Eco.Plan (Pty) Ltd in 2000. Various other environmental projects, including plant relocation trials, the archaeological excavation of a cave and the production of an Environmental Management Plan (EMP) for construction, and environmental design criteria report have been undertaken, concomitant with the various stages leading to the development of Skorpion Zinc.

An EMP for the operation of the Skorpion Zinc mine and refinery was required in terms of Namibian law and was compiled.

The refinery activities generate hazardous waste as part of the operations. Skorpion Zinc is committed to minimise and where possible eliminate hazardous waste. But regardless of all efforts, there is hazardous waste which requires safe disposal. In the past Skorpion Zinc requested safe disposal for hazardous waste at Kupferberg Hazardous Waste Disposal Site outside of Windhoek, but unfortunately it did not materialise. Currently certain hazardous waste produced is accumulating on site and it is against this background, that a solution was urgently needed to resolve the matter. Other hazardous waste (as per classification in the EIA) is disposed of at the Skorpion Zinc tailings dam.

First Amendment to the Skorpion Zinc EMP

Skorpion Zinc commissioned Enviro Solutions and GCS Namibia (Pty) Ltd to carry out a classification of hazardous waste produced by their operations and to investigate various waste disposal options. A document entitled “Disposal of Hazardous Waste at the Skorpion Zinc Mine, Namibia” was compiled and presented to the client. This document was issued to the relevant Government Ministries in an attempt to find a way forward with regard to the safe and legal disposal of hazardous waste.

During the meeting, it was agreed that the existing Skorpion Zinc EMP must be updated to incorporate the recommendations regarding the hazardous waste disposal at Skorpion Zinc. This document was therefore compiled as the first amendment to the existing Operational EMP for the site.
Second Amendment to the Skorpion Zinc EMP

The existing oxide resources at the Skorpion Zinc Mine will be depleted by 2019 and despite extensive exploration drilling for additional zinc oxides, no further resources are available in the area. This means that feed for the existing oxide refinery will no longer be available after the LOM.

With the availability of zinc sulphide concentrates from Black Mountain and Gamsberg in the Northern Cape and new sulphide deposits in the Rosh Pinah region as well as the possibility to import concentrates via the Luderitz port, Vedanta approved the construction of a sulphide plant to enable the existing NamZinc refinery to process zinc sulphide concentrates. Considering the availability of the existing smelting and refining infrastructure, an opportunity was identified not only to sustain zinc production but also to increase capacity to 200 ktpa of zinc production from the current 150 Ktpa.

The existing NamZinc plant was constructed to process oxide ore. In order for the plant to process sulphide zinc concentrates, the plant must be modified to convert the sulphide concentrate to an oxide form (regarded as calcine) which can then be processed in the existing plant via a new leaching circuit. However, by modifying the existing refinery the plant will facilitate the processing of zinc sulphide concentrate along with the oxide ore in the interim (until the LOM) after which zinc sulphide can be treated until approximately 2032.

In order to extend the life of the refinery and maintain the design production rate beyond 2019, Skorpion Zinc (Pty) Ltd plans to treat zinc sulphide concentrates in parallel to the current oxide stream from 2017 to 2021 and then only treat zinc sulphide concentrate until approximately 2032. The treatment of zinc sulphide (ZnS) concentrate will require modification to the existing refinery facilities in order to prepare the sulphide concentrates for refining in the existing plant. The modification will involve the construction of:

- a sulphide roaster
- gas cleaning and acid plant
- calcine leaching facilities

To comply with these requirements, GCS was appointed to obtain regulatory approval to amend Skorpion Zinc’s current Environmental Management Plan (EMP) by taking into consideration the proposed modifications to the existing processing plant and the disposal of additional waste.

After consulting with the Directorate of Environmental Affairs (DEA) on the 1st of December 2014, it was concluded that:
an amendment application should be submitted to the DEA, requesting amendments to the previous Environmental Clearance Certificate;

specialist studies should be undertaken to ensure that the amendment to the EMP takes into account and mitigates potential environmental impacts associated with the modifications; and

public consultation should be undertaken with affected I&APs.

This document was therefore compiled as the second amendment to the existing Operational EMP for the site to accommodate the proposed modifications to the Refinery Plant.
CONTENTS PAGE

1.1 HISTORY ............................................................................................................. 1
1.2 STATE OF ENVIRONMENT .............................................................................. 2
1.3 OPERATIONS EMP ................................................................................................. 3
3.1 OPERATIONAL ACTIVITIES AND INFRASTRUCTURE PLANS ................................. 8
  3.1.1 Technical/Geological activities on site ................................................................. 8
  3.1.2 Mining and mining complex .............................................................................. 9
  3.1.3 Refinery and Training Plant process: Processing of oxides ................................ 12
  3.1.4 Refinery Conversion: Processing of Zinc Sulphide Concentrates ..................... 20
  3.1.5 Purchasing and Stores ...................................................................................... 23
  3.1.6 Engineering ...................................................................................................... 23
  3.1.7 Support Services ............................................................................................... 24
  3.1.8 Environment ...................................................................................................... 25
  3.1.9 Administration and Human Resources ............................................................... 25
6.1 RELEVANT REGULATORY AGENCIES ................................................................ 28
6.2 POLICIES, PLANS AND LEGAL REQUIREMENTS ................................................ 29
  6.2.1 Environmental Management Act (EMA) (Act 7 of 2007) .................................... 29
  6.2.2 Minerals Policy .................................................................................................. 30
  6.2.3 Sperrgebiet ........................................................................................................ 30
6.3 RELEVANT NATIONAL LEGAL CONSIDERATIONS ................................................. 30
  6.3.1 International Conventions ................................................................................. 32
  6.3.2 The Basel Convention ....................................................................................... 32
  6.3.3 The Lome Convention ...................................................................................... 32
  6.3.4 Convention on Biological Diversity ................................................................... 32
  6.3.5 Convention on Combat Desertification (CCD) .................................................. 33
  6.3.6 Sperrgebiet National Park ................................................................................ 33
  6.3.7 Skorpion EIA .................................................................................................... 33
7.1 ROLES AND RESPONSIBILITIES FOR ENVIRONMENTAL MANAGEMENT ................ 34
9.1 THE EMS IMPLEMENTATION APPROACH .............................................................. 39
11.1 ASPECT – EMISSIONS TO AIR (ALL EXCEPT DUST AND SO2) ................. 52
  11.1.1 Background ..................................................................................................... 52
  11.1.2 Legal requirements ......................................................................................... 52
  11.1.3 Goals and objectives ....................................................................................... 52
  11.1.4 Management commitments for all emissions except dust and SO2 ............... 52
  11.1.5 Performance indicators and documentation for measuring compliance to commitments 52
11.2 ASPECT – EMISSIONS TO AIR (DUST) ................................................................. 53
  11.2.1 Background ..................................................................................................... 53
  11.2.2 Legal requirements ......................................................................................... 54
  11.2.3 Goals and objectives ....................................................................................... 54
  11.2.4 Management commitments for dust ................................................................ 54
  11.2.5 Performance indicators and documentation for measuring compliance to commitments 54
11.3 ASPECT – SOx EMISSIONS (SULPHUR DIOXIDE AND SULPHUR TRIOXIDE) ....... 55
  11.3.1 Background ..................................................................................................... 55
  11.3.2 Legal requirements ......................................................................................... 56
  11.3.3 Goals and objectives ....................................................................................... 56
  11.3.4 Management commitments for SOx emissions ................................................ 56
  11.3.5 Performance indicators and documentation for measuring compliance to commitments 56
11.4 ASPECT – EMISSIONS TO LAND (SOLID NON-HAZARDOUS WASTE) .............. 57
  11.4.1 Background ..................................................................................................... 57
  11.4.2 Legal requirements ......................................................................................... 58
11.12.1 Background
11.12.2 Legal requirements
11.12.3 Goals and objectives
11.12.4 Management commitments for the use of manufactured materials
11.12.5 Performance indicators and documentation for measuring compliance to commitments

11.13 ASPECT - VISUAL IMPACT
11.13.1 Background
11.13.2 Legal requirements
11.13.3 Goals and objectives
11.13.4 Management commitments for visual impact
11.13.5 Performance indicators and documentation for measuring compliance to commitments

11.14 ASPECT - VIBRATION
11.14.1 Background
11.14.2 Legal requirements
11.14.3 Goals and objectives
11.14.4 Management commitments for vibration
11.14.5 Performance indicators and documentation for measuring compliance to commitments

11.15 ASPECT - SMELL / ODOR
11.15.1 Background
11.15.2 Legal requirements
11.15.3 Goals and objectives
11.15.4 Management commitments
11.15.5 Performance indicators and documentation for measuring compliance to commitments

11.16 ASPECT - IMPACT ON BIODIVERSITY
11.16.1 Background
11.16.2 Legal requirements
11.16.3 Goals and objectives
11.16.4 Management commitments to biodiversity protection
11.16.5 Performance indicators and documentation for measuring compliance to commitments

11.17 ASPECT - OTHER (E.G. ARCHAEOLOGY, HERITAGE AND HISTORICAL SITES)
11.17.1 Background
11.17.2 Legal requirements
11.17.3 Goals and objectives
11.17.4 Management commitments for archaeology
11.17.5 Performance indicators and documentation for measuring compliance to commitments

11.18 ASPECT - IMPACT ON SOCIO-ECONOMIC & SAFETY AND HEALTH ISSUES
11.18.1 Legal requirements
11.18.2 Goals and objectives
11.18.3 Management commitments to socio-economic, safety and health issues
11.18.4 Performance indicators and documentation for measuring compliance to commitments

11.19 EMERGENCY RESPONSE PROCEDURES
11.20 REHABILITATION, DECOMMISSIONING AND CLOSURE
11.21 NEW PROJECTS / ADDITIONS / TECHNOLOGY OR PROCESS CHANGES
11.22 CUMULATIVE IMPACTS MANAGEMENT

12.1 BI-ANNUAL REPORTING
12.2 MET INSPECTIONS
12.3 EMS AUDITS – ISO 14001
LIST OF FIGURES

Figure 1-1: Regional map ................................................................. 5
Figure 1-2: Locality map ................................................................. 5
Figure 3-1: Plan of the Mining Complex, Open Pit, the Waste Rock Dump and Tailings Impoundment ......................................................... 11
Figure 3-2: Simplified process flowsheet .......................................... 13
Figure 3-3: Process flow-diagram ..................................................... 21
Figure 3-4: Process within the roasting circuit with fugitive gas cleaning plant and gas recovery acid plant ........................................... 22
Figure 7-1: Draft Organogram for Operations showing the possible structure that will be established to manage the EMP and EMS ......................................................... 35
Figure 9-1: The Structure of an Environmental Management System (ISO 14 001) ................................................................. 39
Figure 12-1: Wind speed profiles for surface roughness categories - urban, suburban and open country (http://www.mfe.govt.nz/publications/air/good-practice-guide-atmospheric-dispersion-modelling/4-getting-started) ........................................ 100
Figure 12-2: Series of soil ridges and ditches to limit wind erosion by decreasing wind speed (http://www.fao.org/3/a-x5670e/x5670e06.htm) .................................................. 101
Figure 12-3: Barriers as windbreaks and dust suppression walls (http://www.steelwindbreak.com/1-steel-windbreak-mechanism.html) ........................................... 102
Figure 12-4: Use of solid walls versus controlled porosity fences (http://weathersolve.com/wp-content/uploads/2013/06/wind-pattern-wall-1-940x836.jpg) ............................................. 103
Figure 12-5: Use of fence as wind barrier (Cecala et al., 2012, page 266) ................................................................. 103

LIST OF TABLES

Table 2-1: Mining Licence Details ..................................................... 6
Table 2-2: Fenced area for Skorpion Accessory Works Area (Excluding the access road and Skorpion Air Field) ......................................................... 7
Table 3-1: Major mining equipment .................................................. 8
Table 6-1: Government agencies regulating environmental protection in Namibia ...... 28
Table 6-2: Guarding national regulations and their attributes relevant to the project .... 30
Table 9-1: Ranking of environmental elements affected negatively by Skorpion Zinc in descending order of importance as determined by Leopold Matrix in the original EA in 1998 ................................................................. 36
Table 10-1: Pre-defined Environmental Aspects List used as part of the EMS ............ 40
Table 10-2: Summary Significant Aspects Register for Skorpion Zinc (June 2002) .... 42
Table 10-3: An example of the type of action plans that are developed for each operational area for all aspects that are considered significant ......................... 47

LIST OF APPENDICES

APPENDIX A HAZARDOUS WASTE MANAGEMENT ......................................................... 86
APPENDIX B CURRENT LEGISLATIVE REQUIREMENTS-A SYNOPSIS OF CURRENT LEGISLATION 93
APPENDIX C DUST ENTRAINMENT & SUPPRESSION TECHNIQUES .................................... 99
1 INTRODUCTION

1.1 History

Skorpion Zinc is located in the south-western region of Namibia, some 80km north-east of Oranjemund and 20km north-west of Rosh Pinah. The mine and process plants lie just inside the eastern boundary of a restricted area, Diamond No. 1, also known as the Sperrgebiet (see Figure 1.2).

Although the Skorpion Zinc ore body was first discovered in the seventies, the deposit was not mined at that time as there were metallurgical problems associated with the treatment of the unconventional ore, and the ore body itself was considered too small to be economic in markets prevailing at the time. Reunion Mining Plc entered into an agreement with the Anglo American Corporation in 1997, in terms of which they could earn a percentage interest in the deposit for conducting further drilling, geological work and producing a “bankable” study to develop a mine by September 2000. Reunion did this work, solved the metallurgical problems, piloted the process and produced the bankable study by the end of 1998.

The ore body delineated by Reunion Mining drilling comprised 19.5 million tonnes of ore at an average zinc grade of 10.1%. In 1999 the offshore arm of Anglo American, Minorco, purchased the entire shareholding of Reunion Mining plc to obtain 100% Anglo ownership of the Skorpion deposit. In the same year Anglo merged with Minorco and the resulting company was listed in London as Anglo American plc. Anglo American Plc (AA plc) then bought Reunion Mining’s interest in the ore body and, following additional drilling and bulk sampling for a pilot plant, the go-ahead for the project was approved by the board of AA plc in September 2000 at a capital cost of US$454 million. Construction of the world class Skorpion Zinc mine and refinery commenced in October 2000.

An environmental assessment to World Bank standards was undertaken by Walmsley Environmental Consultants (Pty) Ltd during the project feasibility stage in 1998 and an addendum to this original assessment was produced by Eco.Plan (Pty) Ltd in 2000. Various other environmental projects, including plant relocation trials, the archaeological excavation of a cave and the production of an Environmental Management Plan (EMP) for construction, and environmental design criteria report have been undertaken, concomitant with the various stages leading to the development of Skorpion Zinc.

An EMP for the operation of the Skorpion Zinc mine and refinery was required in terms of Namibian law and was compiled.
The refinery activities generate hazardous waste as part of the operations. Skorpion Zinc is committed to minimise and where possible eliminate hazardous waste, but regardless of all efforts, there is hazardous waste which requires safe disposal. In the past Skorpion Zinc requested safe disposal for hazardous waste at Kupferberg Hazardous Waste Disposal Site outside of Windhoek, but this solution did not materialise. As a result, some hazardous waste is accumulating on site and it is against this background, that a solution was urgently needed to resolve the matter. Other hazardous waste (as per classification in the EIA) is disposed of at the Skorpion Zinc tailings dam.

Skorpion Zinc commissioned Enviro Solutions and GCS Namibia (Pty) Ltd to carry out a classification of hazardous waste produced by their operations and to investigate various waste disposal options. A document entitled “Disposal of Hazardous Waste at the Skorpion Zinc Mine, Namibia” was compiled and presented to the client. This document was issued to the relevant Government Ministries in an attempt to find a way forward with regard to the safe and legal disposal of hazardous waste.

On the 28th of May 2010 a meeting was held, in which the findings outlined in the report and the way forward was discussed. During the meeting, it was agreed that the existing Skorpion Zinc EMP must be updated to incorporate the recommendations regarding the hazardous waste disposal at Skorpion Zinc. This document was therefore compiled as the first amendment to the existing Operational EMP for the site.

1.2 State of environment

The existing oxide resources at the Skorpion Zinc Mine will be depleted by 2019 and despite extensive exploration drilling for additional zinc oxides, no further resources are available in the area. This means that feed for the existing oxide refinery will no longer be available after the LOM.

The availability of zinc sulphide concentrates from Black Mountain and Gamsberg in the Northern Cape and new sulphide deposits in the Rosh Pinah region as well as the possibility to import concentrates via the Luderitz port resulted in Vedanta approving the construction of a sulphide plant to enable the existing NamZinc refinery to process zinc sulphide concentrates. Considering the availability of the existing smelting and refining infrastructure, an opportunity was identified not only sustain zinc production but also to increase capacity to 200 Ktpa of zinc production from the current 150 Ktpa.
The existing NamZinc plant was constructed to process oxide ore. In order for the plant to process zinc sulphide concentrates, the plant must be modified to convert the sulphide concentrates to an oxide form (regarded as calcine) which can then be processed in the existing plant via a new calcine leaching circuit. However, by modifying the existing refinery the plant will facilitate the processing of zinc sulphide concentrate along with the oxide ore in the interim (until the LOM) after which zinc sulphide can be treated until approximately 2032.

GCS was therefore appointed in 2014 to obtain regulatory approval to amend Skorpion Zinc’s current Environmental Management Plan (EMP) by taking into consideration the proposed modifications to the existing processing plant and the disposal of additional waste.

After consulting with the Directorate of Environmental Affairs (DEA) on the 1st of December 2014, it was concluded that (See Appendix A):

- an amendment application should be submitted to the DEA, requesting amendments to the previous Environmental Clearance Certificate;
- specialist studies should be undertaken to ensure that the amendment to the EMP takes into account and mitigates potential environmental impacts associated with the modifications; and
- public consultation should be undertaken with affected I&APs.

Therefore, this document serves as the second amendment to the existing Operational EMP for the site to accommodate the proposed modifications to the Refinery Plant.

1.3 Operations EMP

The Skorpion Zinc Operations EMP cannot be viewed in isolation. There are several environmental reports that have been produced since 1988 that should be consulted as they provide the supporting bio-physical and socio-economic information that underpins this Operations EMP. These reports include the Skorpion Zinc Environmental Assessment (EA), The Skorpion Zinc Environmental Assessment Addendum (EA Addendum), Skorpion Zinc Project Design Criteria, the Skorpion Zinc Environmental Management Plan (EMP) for Construction, the Disposal of Hazardous Waste at the Skorpion Zinc Mine Report (2010) and more recently the Skorpion Zinc Refinery Sulphide Conversion Amendment to EIA Report (2015). These documents, with the exception of the Design Criteria, are lodged with the Ministry of Mines and Energy (MME) and with the Ministry of Environment and Tourism (MET).
During drafting of the original Operations EMP the guideline document, “Generic EMP for Prospecting and Mining in Namibia”, produced by the Ministry of Environment and Tourism was consulted as it is generally attached as an appendix to the Environmental Contract that is signed between the proponent (in this case, Skorpion Zinc) and the Government of Namibia. The draft “General Environmental Assessment Guideline for the Mining Sector of Namibia” was also consulted.

The Operations EMP is designed to document Skorpion Zinc’s overall commitment to minimising the negative impacts and optimising the positive impacts of its operations on the environment.
Figure 1-1: Regional map
Figure 1-2: Locality map
2 MINING LICENSE HOLDER’S DETAILS

In early 2010, Vedanta Resources Plc acquired the Skorpion Zinc Mine from Anglo American Plc. Vedanta currently owns the two companies that control the mine:

Namzinc (Pty) Ltd:
- Refinery;
- Skorpion Rosh Pinah town & associated infrastructure;
- Offices; and
- Luderitz port facility

The Skorpion Mining Company (Pty) Ltd:
- Open pit;
- Tailings dam;
- Waste rock dumps; and
- Mine offices and workshops.

<table>
<thead>
<tr>
<th>Table 2-1: Mining Licence Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of Holder</strong></td>
</tr>
<tr>
<td>Vedanta Resources Plc</td>
</tr>
<tr>
<td><strong>Name of CEO / Director</strong></td>
</tr>
<tr>
<td>P O Box 40669, Ausspanplatz, Windhoek, Namibia</td>
</tr>
<tr>
<td><strong>Contact details</strong></td>
</tr>
<tr>
<td>3rd Floor SWA Building Society</td>
</tr>
<tr>
<td>7 Post Street Mall, Windhoek, Namibia.</td>
</tr>
<tr>
<td><strong>Postal / Registered Address</strong></td>
</tr>
<tr>
<td><strong>Reference No of the licence</strong></td>
</tr>
<tr>
<td>14/2/3/2/108</td>
</tr>
<tr>
<td><strong>Locality of Mining Licence</strong></td>
</tr>
<tr>
<td>Karas Region, Lüderitz district</td>
</tr>
<tr>
<td><strong>Corner Point No</strong></td>
</tr>
<tr>
<td><strong>Latitude</strong></td>
</tr>
<tr>
<td><strong>Longitude</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>-27.80471856</td>
</tr>
<tr>
<td>16.60539169</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>-27.83194291</td>
</tr>
<tr>
<td>16.62144294</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>-27.83166272</td>
</tr>
<tr>
<td>16.58388909</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>-27.80471992</td>
</tr>
<tr>
<td>16.58388850</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>-27.80475470</td>
</tr>
<tr>
<td>16.60539158</td>
</tr>
<tr>
<td><strong>Total Area</strong></td>
</tr>
<tr>
<td>951ha</td>
</tr>
<tr>
<td><strong>Minerals to be mined</strong></td>
</tr>
<tr>
<td>Precious, Base and Rare Metals</td>
</tr>
</tbody>
</table>
The mining licence area differs from the area of land that is fenced out of the Sperrgebiet.

Table 2-2: Fenced area for Skorpion Accessory Works Area (Excluding the access road and Skorpion Air Field)

<table>
<thead>
<tr>
<th>Corner Point No</th>
<th>Northing</th>
<th>Easting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Co-ordinate System: Bessels 22/17)</td>
</tr>
<tr>
<td>A</td>
<td>39745</td>
<td>641461</td>
</tr>
<tr>
<td>B</td>
<td>41506</td>
<td>641465</td>
</tr>
<tr>
<td>C</td>
<td>41508</td>
<td>644096</td>
</tr>
<tr>
<td>D</td>
<td>39003</td>
<td>646610</td>
</tr>
<tr>
<td>E</td>
<td>36979</td>
<td>646582</td>
</tr>
<tr>
<td><strong>Total Area</strong></td>
<td>1305ha</td>
<td></td>
</tr>
</tbody>
</table>
3 PROJECT DESCRIPTION

3.1 Operational activities and infrastructure plans

The following sub-sections describe in detail the activities currently underway at Skorpion and give a high-level overview of the operational activities. Plans of each of the area are included in the relevant section.

The “Generic EMP for Prospecting and Mining in Namibia” requires that a list of the type and quantity of each of the different vehicles, earth-moving and drilling equipment and other machinery is included in the EMP (Table 3.1). This information is provided for mining. Generally the movement of this machinery will be confined to the operational areas of the mine and refinery. Private vehicles, transport trucks and bulk fuel carriers etc. are not included.

<table>
<thead>
<tr>
<th>No of Vehicles</th>
<th>Vehicle Description</th>
<th>No of Vehicles</th>
<th>Vehicle Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-10</td>
<td>haul trucks</td>
<td>1-2</td>
<td>drill and rig</td>
</tr>
<tr>
<td>1</td>
<td>fuel truck</td>
<td>1</td>
<td>ANFO pump truck</td>
</tr>
<tr>
<td>2</td>
<td>wheeled dozers</td>
<td>1</td>
<td>truck tractor</td>
</tr>
<tr>
<td>2</td>
<td>water trucks</td>
<td>1</td>
<td>front end loader</td>
</tr>
<tr>
<td>1</td>
<td>grader</td>
<td>1</td>
<td>service truck with crane</td>
</tr>
<tr>
<td>1</td>
<td>tyre handler</td>
<td>1</td>
<td>55 tonne mobile crane</td>
</tr>
<tr>
<td>1</td>
<td>explosives truck</td>
<td>1-2</td>
<td>hydraulic excavator</td>
</tr>
<tr>
<td>1</td>
<td>track dozer</td>
<td>1</td>
<td>2,5tonne explosives depot forklift</td>
</tr>
<tr>
<td>1</td>
<td>lube truck</td>
<td>10</td>
<td>LDV’s : 2x4 single cabs (x3), 4x4 double cab (x1), 4x4 single cab (x1), 4x2 single cabs (x5) (all diesel - mining only)</td>
</tr>
</tbody>
</table>

3.1.1 Technical/Geological activities on site

Skorpion Zinc have geological and survey teams as part of the mining department’s technical services. Geological exploration on the mine property consist of diamond and reverse circulation (RC) drilling ahead of mining operations to determine ore grades, and for detailed geological mapping of unconfirmed ore reserves. Core and the samples from both diamond and RC drilling are analysed by the laboratory on site. The geological department are also responsible for directing the drill rig in the pit in order to get grade control drill samples for analysis.

The survey department surveys in sample points and monitor the pit, waste rock dump, ore stockpiles and tailings impoundment advance as a support service to the mining operations.
Mining and mining complex

Ore reserve calculations indicate that reserves at a cut-off grade of 4.6% are some 21.4Mt at an average grade of 10.6% zinc with an estimated at life of mine of 15 years. In order to extract this ore, an open pit measuring 1 000m by 700m and some 240m deep will be developed (Figure 3-1). The open pit will be mined by conventional truck and shovel methods and will operate on a 24-hour, seven days a week basis. Ore will be selectively mined during daylight hours to avoid excessive contamination by limestone. Waste rock will be mined both day and night.

Some of the overburden material from the open pit was removed during construction to expose the ore. The overburden, consisting primarily of calcretes, was used for the construction of the haulage roads, evaporation ponds and tailings impoundment walls.

The first stage in the ore extraction process is the blasting of overburden, waste rock and ore. A tracked drill rig will drill blast holes for the explosives. Blasting will occur on a reduced scale for the first few years, after which it will occur about once a week. Specialised pre-split blasting will be required from 2003 when the upper bench reaches its final limit. Explosives and detonators will be stored at the explosive magazines 1 500m to the north-west of the pit.

The pit will be mined in multiple benches ranging between 2.5m and 10m. Every 50m in depth there will be an enlarged catchment berm. With the removal of some of the overburden during the construction phase, the stripping ratio will be fairly high until year 2004 when the volumes of ore will increase in relation to the waste mined.

A canon water jet will be mounted to the top of two water bowsers that will be used to suppress dust on muck piles during loading operations. Furthermore, both of the vehicles will have a rear spray to continuously dampen the 25m wide haulage roads to control dust. Water for dust suppression may be obtained from the evaporation pond or the effluent water from the sewage plant. Chemical dust suppressants will also be considered.

The ore will be blended to between 9% and 13% zinc via a defined stockpiling system outside of the pit before being transported to the crushers. The mine cut-off grade is 4.6% zinc and any marginal ore, i.e. less than the cut-off grade, will be stockpiled for possible processing towards the end of the life of mine if considered economically viable. There will be four stockpiles at the crusher pad, a low, medium and high grade, as well as a limestone stockpile.

The final pit shape will be more or less oval, with overall pit slope angles between 36° and 45° and the inter-ramp slope angles will be between 47° and 53°. Two 25m wide haulage roads will emerge from the pit, one to the tip and the other to the tailings impoundment.
and waste rock dumps. A haul road will circle the rim of the pit and there will be a road to the limestone quarry.

The mining complex illustrated on Figure 3-1 comprises change houses, a laundry, lunchroom, wash and tyre bays, refuelling depot, a guardhouse and the mining vehicle and equipment maintenance workshop.
Figure 3-1 Plan of the Mining Complex, Open Pit, the Waste Rock Dump and Tailings Impoundment

- Plant Upgrade area (Currently used as a lay down area)
- New lay down area
- Construction Camp
- Existing Processing Plant
Limestone quarry
The original EA Skorpion Zinc indicted that the limestone needed for the acid neutralisation process in the refinery would have to be sourced from the limestone outcrop located to the east of the mine and refinery property (Figure 2-1). At the end of the feasibility study the conclusion had been reached that the limestone could probably be obtained from the pit. Skorpion Zinc did however, indicate that the limestone outcrop may still be mined should suitable quality limestone not be found in the pit.

At present, it appears that it will be necessary to quarry the limestone outcrop for at least the first three years of production at Skorpion Zinc. The outcrop will be drilled and blasted once or twice per month and the rock will be stockpiled in the vicinity of the quarry until required in the refinery. It will then be loaded and transported, utilizing existing mining equipment, to the limestone crusher, situated north of the plant. The limestone will be converted to milk of lime via a wet milling process (Figure 3-2). Rehabilitation plans will be established for the quarry.

Limestone will remain one of the key reagents to the Refinery when processing zinc sulphide concentrates after mine closure. During oxide life, sufficient limestone will be stockpiled for around 15 years of operation of the Refinery Conversion Project. After this time, limestone will have to be mined again. The limestone outcrop will be considered as alternative source to the limestone in the closed Skorpion Pit.

3.1.3 Refinery and Training Plant process: Processing of oxides
The Skorpion Zinc ore is considerably different from the usual sulphide ore bodies and thus the zinc cannot be recovered using the more common sulphide flotation processes such as that used at Rosh Pinah Zinc Corporation. The Skorpion Zinc process uses acid leach and neutralisation to produce pregnant liquor that is further purified by solvent extraction. The resultant loaded electrolyte is of sufficiently high quality that it can then be used for zinc electrowinning onto aluminium cathodes that are subsequently melted and cast into special high-grade (SHG) ingots for export.

The training plant was designed to provide future plant operators with a training facility in which to familiarise themselves with the operation of the full-scale zinc refinery. The training plant is a scaled-down version of the main refinery. The main refinery process will be described in the following sections.
Figure 3-2 Simplified process flowsheet

(3.1.3.1) Numbers refer to the text description in the document.
3.1.3.1 Ore Crushing and Screening - Comminution

The run of mine ore from the open pit will be fed into the 3-stage crushing and screening circuit at a rate of ±460 tonnes per hour. The crusher product will be screened and the oversize (>100mm) will be returned to the crusher feed bin whilst the -12mm fraction is conveyed to the stockpile under a dome enclosed stacker-reclaimer system (Figure 3.2). The stacker-reclaimer has several purposes: to enable the ore to be homogenised to provide a consistent grade to the refinery, to prevent natural dust from contaminating the ore, and to prevent valuable ore from being blown into the desert. Fine water sprays will be used at the crusher and various tipping points to control fugitive dust.

3.1.3.2 Ore Milling and Thickening (Figure 3-2)

The crushed ore from the stacker-reclaimer stockpile will then be conveyed to a single semi-autogenous grinding mill to be reduced 100%-0,5mm. Oversize material will be screened out and returned to the mill feed hopper for re-milling. The undersize material (-0,5mm) will be pumped to a thickener. The thickener overflow will gravitate to a mill return water tank and then back to the mill whilst the underflow with a solids content of 40-50% will be pumped to the leach section.

3.1.3.3 Atmospheric Acid Leaching

The refinery thickener underflow slurry from the milling section will be diluted with acidic raffinate recycled from the solvent extraction section before concentrated sulphuric acid at 98% acid is added to leach the zinc (and other metals) from the ore at pH 1-2. Leaching will take place at 50°C in a six-tank cascade over a 2-hour period. Acid for this process is obtained from the sulphuric acid plant described in Section 3.1.3.10.
3.1.3.4 Neutralisation, Residue Thickening, Re-Acidification, Filtration and Disposal

The neutralisation step removes ferric iron (Fe$^{3+}$) and aluminium from the solution as precipitated solids. Neutralisation is achieved by adding basic zinc sulphate and limestone to achieve a final pH of 4 - 4.2 and to precipitate the impurities of iron and aluminium. During this approximately 3-4 hour stage, the temperature ($50^\circ +$) and pH are carefully controlled to produce a filterable solids residue by avoiding the formation of silica gel.

Following neutralisation, the slurry is fed to a second thickener in order to recover as much pregnant liquor solution (PLS) as possible. This thickener overflow now contains about 80% of the dissolved zinc from the slurry fed to the first thickener and is pumped to the unclarified leach solution tanks.

The remaining 20% of the dissolved zinc, as well as the undissolved zinc remaining in the solid leach residue, will report to thickener underflow, which will be pumped at about 30% solids to the re-acidification step where any zinc that may have precipitated during the neutralisation stage is redissolved to prevent it from being lost with the solids residue.

The slurry from re-acidification is pumped to the residue (tailings) filters where it is filtered and washed by belt filtration with two steps of counter current washing. The soft biscuit like residue is disposed of as a filter cake on the tailings impoundment. The filter cake will have a pH of about 3 and will contain 38-42% moisture, 15-25% being water of crystallisation and the rest surface water, some of which will be lost to evaporation in the tailings impoundment.

3.1.3.5 Impurity Control (impurity cementation, basic zinc sulphate (BZS) precipitation)

Basic Zinc Sulphate (BZS)

The objective of the basic zinc sulphate circuit is to precipitate and recover soluble zinc that has to be bled from the main circuits in order to maintain the overall water balance. Zinc is recovered from the bleed solution (from the secondary belt filter and pregnant liquor solution) by neutralisation to a pH of 5-5.5 with limestone and milk of lime, resulting in the precipitation of basic zinc sulphate. The precipitated basic zinc sulphate and other solids are separated from the bleed solution by thickening and filtration and are sent back to the neutralisation stage in the leach process. The overflow solution from the BZS circuit is partly re-used for filter cake washing, with the remainder sent to the effluent treatment plant where the remaining impurity elements are precipitated at a pH of 10 with lime.
**Impurity Cementation**

During the leaching process, several impurities such as copper, cobalt, nickel, and cadmium are leached from the ore that also have to be removed from the process. This is done by taking a bleed stream of thickener overflow and adding metallic zinc dust that causes the impurities to precipitate out of the solution cement onto the zinc dust. The resulting slurry is filtered to produce a saleable copper / nickel / cobalt / cadmium filter cake. The filtrate is recycled to the milling circuit. The filter cake will be stockpiled in one tonne tuff bags until they are utilised, or sold, or disposed of at an appropriate facility.

### 3.1.3.6 Solvent Extraction

The objective of the solvent extraction circuit is to selectively extract and upgraded the zinc from the leach solution so that the resulting solution can be utilised in the electrowinning circuit without further purification. (The process described below can be likened to the mixing of oil and water into an emulsion and the transfer of the dissolved product from one solution to another.)

The filtered PLS fed to the solvent extraction circuit is mixed counter-currently with the organic raffinate in three extraction stages. The aqueous (PLS) and organic (D2EPHA) phases are mixed and zinc and iron are transferred from the PLS to the organic phase by the transfer mechanism:

- \( 2HR_{ORGANIC} + ZnSO_4 \rightarrow R_2Zn_{ORGANIC} + H_2SO_4 \)

“HR” in the reaction above is D2EPHA, (Di-2-ethyl hexyl phosphoric acid) which is diluted with kerosene to act as the carrier and reduce the viscosity of the organic phase.

The resulting emulsion is then allowed to separate in the settler to yield two phases. The aqueous raffinate (stripped) containing the sulphuric acid is recycled back to the acid leach tanks. The loaded organic which contains the zinc and small amounts of iron and base metals is then processed further in three washing stages in which the co-extracted base metals are displaced from the organic phase, leaving only zinc and iron in the organic.

The wash solutions are combined and exit the circuit with the aqueous raffinate to return to the start of the solvent extraction process whilst the loaded organic proceeds to the stripping circuit.

In the stripping circuit the spent electrolyte from the electrowinning process is used to strip the zinc from the organic. The strip reaction takes place in two stages and is basically the reversal of the earlier extraction reaction:

- \( R_2Zn_{ORGANIC} + H_2SO_4 \rightarrow 2HR_{ORGANIC} + ZnSO_4 \)

The loaded electrolyte becomes the feed liquor for the electrowinning cell house and the stripped organic raffinate is recycled back to the extraction circuit.
3.1.3.7 Organic regeneration

The very small quantity of ferric iron present in the acid leach solution, which is co-extracted with the zinc by the D2EHPA, will build up in the organic and create problems in the circuit. In order to prevent this, an organic regeneration step has been incorporated in the process in which a bleed stream of the stripped organic raffinate is mixed with concentrated hydrochloric acid. Iron is then transferred from the organic phase according to the reaction:

\[ R_3Fe_{\text{ORGANIC}} + 3HCl \rightarrow 3HR_{\text{ORGANIC}} + FeCl_3 \]

The products are an iron-free organic raffinate stream, which is recycled back to the organic raffinate surge tank, and a contaminated stream of hydrochloric acid that flows to the acid regeneration system.

3.1.3.8 Zinc Electrowinning

The electrolyte from the solvent extraction stage will be pumped via cooling towers to a surge tank and then to the electrowinning cells, where zinc will be plated onto aluminium cathodes. The spent electrolyte, still containing some 40g/l zinc will be returned to the stripping section of the solvent extraction. Various reagents, such as manganese dioxide and gum arabic, will be added at the surge tank to ensure good cathode quality and maintain the required electrical current efficiency. Once the zinc has been plated onto the cathodes, they will be lifted by an electric hoist from the cells and washed and stripped. Stripping of the zinc from the cathodes will be done mechanically.

3.1.3.9 Melting and Casting

The stripped plated zinc is stored before being discharged into the induction furnace and melted. The molten zinc will flow to a casting machine that produces ingots of 99,995% zinc of two different kinds. The 25kg ingots will be stacked, strapped, weighed and stored prior to transportation by truck to Lüderitz harbour. The 1 tonne jumbo ingots are large and are transported singly.

Due to surface oxidation during the melting and casting process, some zinc-containing dross and skimmings are produced. The metallic portion of the dross and skimmings is returned to the furnace, while the oxide portion is returned to the leach process for zinc recovery.

3.1.3.10 Sulphuric Acid Plant.

The sulphuric acid to be used in the refinery process will be produced on site by burning sulphur in a state-of-the-art proprietary acid plant. The acid plant will produce sulphuric acid at 98,5%. The \( SO_2 \) to \( SO_3 \) conversion efficiency will be 99,8% due to a 5-pass converter tower in contrast to the more usual 4 passes.
The elemental sulphur will be in the form of prills (pellets) delivered to the site in bulk shipment to Luderitz and bulk handling transport to the site and stockpiled in enclosed storage area containing all the necessary fire detection and control equipment. It is anticipated that the plant will be shut down every second year for maintenance. Therefore acid plant pre-heating and start-ups will occur less frequently than originally anticipated. Approximately 25 000ℓ of diesel fuel will be used during pre-heating. Thereafter, the necessary heat is provided by the combustion of the sulphur. The sulphur dioxide (SO\(_2\)) will be cooled and the energy used to provide process heating steam before passing to the converter, where SO\(_2\) will be converted to SO\(_3\) using four passes of vanadium pentoxide (V\(_2\)O\(_5\)) catalyst to ensure complete conversion to SO\(_3\).

After the last pass, the gas will be cooled before entering the final absorption tower, where the SO\(_3\) is absorbed in a counter-current flow of 98,5% sulphuric acid. The depleted gases will then be vented to the atmosphere via the recommended 60m high stack. The 98,5% sulphuric acid will be stored in large bunded storage tanks ready for use in the plant.

A cooling tower and pumps will supply cooling water to the acid coolers and the main blower oil cooler. The cooling water will be treated with a biocide, probably chlorine, to reduce fouling in the cooling tower.

3.1.3.11 Effluent Treatment Plant and Evaporation Ponds

All waste effluents that cannot be recycled in the process plant will report to the effluent treatment plant (ETP). Sources of effluent include the boiler blowdown, the laboratory, cooling tower blowdown, the demineralisation plant, basic zinc sulphate plant and occasional spills or overflows in the refinery.

Lime slurry will be added to the effluent in the ETP to raise the pH to 10. The final effluent slurry is filtered to produce clean process water, most of which is recycled for reuse in the plant. Excess process water is discharged to the evaporation ponds. The solid cake from the filter is blended with the filter cake residue and sent to the tailings impoundment. Excess treated effluent from the plant will be directed to one of the top 2 ponds of the 6 evaporation ponds for disposal where the solution will flow from one side of the pond to the other before cascading into the next pond, allowing adequate time for any entrained solids to settle. All the evaporation ponds are lined with 2mm UV resistant HDPE. The residue in the ponds (mainly gypsum and minor amounts of metallic salts) will be cleaned periodically by washing them with ETP filtrate from a movable tripod-mounted spray nozzle. The slurry will be pumped back to the effluent treatment plant for filtration and ultimate disposal on the tailings conveyor belt. Available water will be pumped from the first ponds for dust suppression at the mine, or will evaporate.
3.1.3.12 Tailings impoundment

The filter cake residue (tailings) will be disposed of in a tailings impoundment located to the north of the mine and refinery facilities (Figures 2.1 and 3.1). The residue is conveyed as a filter cake product (almost like a wet dog biscuit) from the vacuum belt filters at the processing plant and will be dispersed within the impoundment walls that are constructed of waste rock. The conveyor will run for some 2 kilometres along the Sperrgebiet eastern boundary and onto the tailings impoundment via a 40m high ramp. The tailings will be spread onto the advancing face of the tailings pile by a mobile spreader conveyor. Waste rock will be used to cover the surface of the tailings as the impoundment advances westwards. This method of disposal was designed to minimise dust emissions from the impoundment.

3.1.3.13 Training Plant

The first ore used in the training plant was obtained from the bulk sampling stage prior to the construction of the Skorpion Zinc project. The crushed and screened ore is stored in 1 tonne tuff bags and used as and when required. The bagged ore is hoisted and fed into a surge bin before being ground in a small ball mill. The process that is followed is the same as that described for the refinery but on a miniature scale (1:1400). The concentrated (98.5%) sulphuric acid is however, not made on site, but is off-loaded from a bulk container or 25lt drums on a batch basis. The training plant will be ‘mothballed’ as the operators begin to familiarise themselves with their work in the main refinery, but can be used for process optimisation in the future, or for the treatment of atypical ores.

3.1.3.14 Laboratory

All pit samples and process samples from the refinery will be analysed in the laboratory on site. A sophisticated robot has been installed to automate part of the sampling process. In addition, there is a wet lab, a XRF room and an AA/ICP room. The laboratory is well ventilated and has an acid fume extraction and scrubbing system as well as a dust extraction system. All effluents from the laboratory are directed to the effluent treatment plant at the refinery. The day-to-day operation of the laboratory has been contracted out.

3.1.3.15 Lüderitz Warehouse

The Skorpion warehouse at the Lüderitz Harbour falls within NamPort’s facilities and is subject therefore to both Skorpion Zinc’s and NamPort’s EMP and EMS. NamPort will off-load bagged sulphur prills from the ships and onto trailers. The trailers will then be off-loaded at the Skorpion warehouse where the bags are stored until they are loaded again for transport by a contracted haulier for delivery to the Skorpion Zinc refinery.

Zinc ingots will be delivered to the Lüderitz warehouse before being loaded onto ships, by NamPort, for export to the world market. The warehouse at Lüderitz will fall under Skorpion Zinc’s EMP and EMS.
3.1.4 Refinery Conversion: Processing of Zinc Sulphide Concentrates

To avoid closure of the current Skorpion Zinc refinery, there is an opportunity to treat Zinc Sulphide (ZnS) concentrates utilizing the existing plant but with some modifications (referred to as the refinery conversion process). This implementation will be conducted in two phases:

- Phase 1: Parallel processing of ZnO from the current pit and ZnS concentrates to produce 200 ktpa of Zn (50 ktpa from oxides and 150 ktpa from sulphide concentrates).
- Phase 2: Processing of ZnS concentrates only through the new roaster and leaching circuits and then the existing plant to produce 150ktpa of Zn.

In order to facilitate the zinc sulphide concentrates processing, the following additions to the current plant will be required:

- Bulk handling and storage of Zn Sulphide concentrates;
- The construction of a roasting circuit with gas cleaning plant and gas recovery acid plant.
- The installation and integration of a new calcine leach circuit.

The new infrastructure will be constructed on the “accessory works area”, which is to the east of the current processing plant.

The new sulphide circuit comprises of the following major sections (Figure 3-3 Process flow-diagram):

- Concentrate handling system
- Roaster
- Wet Gas cleaning Plant (WGP)
- Acid Plant
- Calcine handling system
- Calcine leach circuit
3.1.4.1 **Bulk handling and storage of Sulphide Zinc concentrates**

The concentrate will be transported by road from the Gamsberg mine in South Africa (The transport route will be addressed in another EIA). The 50% ZnS Concentrate from Gamsberg is offloaded through feed hoppers and conveyed onto storage stockpiles (i.e. different stockpiles for different concentrate feed material). The ZnS Concentrate is blended using belt feeders and then conveyed to the roaster area for processing.

![Process flow diagram](image_url)

**Figure 3-3 Process flow-diagram**
3.1.4.2 The construction of a roasting circuit with fugitive gas cleaning plant and gas recovery acid plant.

The zinc concentrates are fed to a fluidised bed roaster (Figure 3-4 Process within the roasting circuit with fugitive gas cleaning plant and gas recovery acid plant). Blowers force air into the roaster where it reacts at 950°C with the zinc sulphide to produce a sulphur dioxide off gas and zinc oxide (calcine). Iron sulphide is converted into a ferrite of zinc. The calcine is stockpiled before being transported to the Soft Calcine Leach. The calcine requires a calcine handling system for feeding the leaching section. The roaster off-gas is treated in an off-gas handling facility to reduce the temperature and remove fine dust and fume condensate particles.

A waste heat boiler is used to recover heat from the roaster system, first to generate power and then to provide heating to the combined circuit in the form of medium pressure steam.

Figure 3-4 Process within the roasting circuit with fugitive gas cleaning plant and gas recovery acid plant

The roaster gas is further treated to remove mercury (in order to meet the provided CP acid specification) and then dried before being transported to the acid plant where the sulphur dioxide gas is converted into a concentrated sulphuric acid product.
3.1.4.3 The installation and integration of a new calcine leach circuit with the existing equipment

This circuit involves a soft calcine and strong ferrite leach stage. Most of the zinc oxide in calcine is recovered in the soft calcine leach stage (operating at approx. 60°C) and the target end acidity of the liquor from this section is 5g/l H₂SO₄. Ferric zinc will be leached in the strong ferrite leach circuit. Zinc rich solution from the sulphide circuit (i.e. overflow after thickening) will combine with the current oxide leach slurry in the current oxide neutralisation stage. Iron precipitation will take place in this neutralisation circuit where iron is precipitated as goethite. The combined goethite tailings (neutralisation residue) produced, have similar properties to the current oxide tailings. This means that the calcine leach residue produced from the ferrite leach circuit will be neutralised with limestone at a ratio 1:1 and co-disposed with the neutralisation residue at the current TSF.

3.1.5 Purchasing and Stores

There will be central control over the full range of purchasing activities including raw materials, facilities/administration supplies and contractors/services. For certain contracts, e.g. the Luderitz warehouse and the laboratory, the contractor will purchase their own items but Skorpion Zinc policy will influence the acceptable products list. The major activities of the purchasing department that will influence environmental performance are listed below:

- Identification and approval of items to be purchased (stock and specials);
- Tender process including evaluation criteria, adjudication and selection of suppliers;
- Preparation of supplier contracts;
- Monitoring of supplier performance, including contract review and re-negotiation;
- Control over goods in and out (including waste materials, out-of-spec. goods, goods deliveries);
- Storage of materials (responsibility shared with materials users);
- Communication regarding materials/service contracts to users;
- Stock control and ordering.
3.1.6  Engineering

3.1.6.1  Maintenance and Repairs

The engineering department is responsible for the maintenance and repair of the equipment and facilities listed below, although other departments or contractors will manage certain of these areas. For example, NamWater supplies water to site, but the engineering department will be responsible for the water reticulation system on site. The sewage treatment plants will be managed by a contractor but will be serviced by engineering.

- Air conditioning / heating systems;
- Building repairs (for non production areas) such as administration, laundry facilities;
- Electrical sub-stations;
- Water reticulation on site;
- Sewage reticulation and treatment;
- Road repairs;
- Construction and demolition;
- General workshop and oil sumps / silt traps;
- Skorpion site landscaping and garden maintenance;
- Laundry facilities.

3.1.7  Support Services

3.1.7.1  Fuel supplies

A fuel supplier has been contracted to provide petrol and diesel to Skorpion Zinc and to manage the refuelling facilities at the mining complex and in the refinery area near the administrative buildings. The mining complex refuelling bay has two aboveground fuel tanks that are linked to the oil separation system in case of accidental spills. A small diesel tank is situated underground at the refuelling station at the mine change house. The diesel for the acid plant preheat will also be stored in above ground tanks at the acid plant.

The fuel supplier will also manage the tanks for the temporary storage of waste oil and will ensure the safe disposal thereof off site. Skorpion Zinc will ensure that the contracted fuel supplier disposes of waste oil safely. More than one accredited buyer will be sourced to ensure that someone is always available to take the waste oil.
3.1.7.2  Transport
The bulk of the raw materials to be transported to site will be sulphur prills, and diesel, with LPG gas, oil, plant reagents, consumables, mine and refinery maintenance equipment and explosives making up the balance. The volume of sulphur to be transported will require an estimated 14 trucks per day to travel daily between Lüderitz and Rosh Pinah. The refined SHG zinc ingots produced at Skorpion will be transported on the trucks returning to Lüderitz. The transport of all goods will be contracted out to independent hauliers.

3.1.7.3  Solid Waste Management
Non-hazardous waste
A waste management system has been installed on site that includes a pilot waste separation project aimed at the collection baling and sale of cans, paper, glass and plastic to recycling companies. General waste is currently being disposed of at a temporary landfill in the footprint of the waste rock dump and will be disposed of at the new landfill site in Rosh Pinah once this has been constructed. The same waste management system applies to the Skorpion Zinc site and homes in Rosh Pinah. Any contractors contracted to manage the waste systems will be required to manage waste according to Skorpion Zinc’s EMP and EMS requirements.

Hazardous waste
The following overall precepts will be applied to waste management and Section 12.5 lists the commitments to responsible waste management for the mine and refinery.

Hazardous materials/ containers will be returned to the supplier where practical and within the conditions of the Basel Convention.

Alternatively, Skorpion Zinc or contractors will be held responsible for the safe disposal of their hazardous waste at an approved facility.

Sewage Effluent
All the ablution facilities at Skorpion Zinc are linked to the sewage treatment plant situated at the southern side of site (Figure 2.1). The sewage plant is a compact system and comprises a combined primary settlement tank and anaerobic digester (septic tank) that flows into a secondary aerobic process consisting of bio-filter fixed film discs that rotate at 5rpm. The effluent then flows into a humus settlement and disinfection tank where chlorine can be added to purify the water to a standard acceptable for use on sports fields and gardens if required, or to be discharged into a natural waterway. The effluent water that is not recycled is discharged into the nearby streambed. Three sewage plants have been installed in Rosh Pinah to accommodate the sewage from the Skorpion homes. The sewage faculties, at both Skorpion Zinc and Rosh Pinah, are permitted by the Department of Water Affairs under the Ministry of Agriculture, Water and Rural Development (MWARD).

The primary tanks require de-sludging periodically (once to twice a year) and the sludge that is removed will be disposed of in trenches located at the foot of the advancing waste rock face, as per the conditions of the MWARD permits.

3.1.8 Environment

The environmental department will monitor the implementation of, and adherence to, any environment related issues such as the Skorpion EMP and EMS, permits issued by the various authorities, various monitoring programmes, and new project environmental assessments, amongst others. The department will provide an advisory role to the mine and refinery and will assist in the promotion of environmental awareness.

3.1.9 Administration and Human Resources

3.1.9.1 Clinic and Other Medical Services

Extensions have been made to the existing recreational facilities and crèche in Rosh Pinah and the clinic and crèche have been upgraded.

3.1.9.2 Shift Worker’s Village, Guest House, Laundries and Cleaning and Catering Contractors

Shift workers are accommodated in a complex situated near the entrance to Rosh Pinah. Small flatlets have been built for the workers and meals are provided at a central dining and recreational facility. Any contractors contracted to manage the shift workers hotel will be required work within Skorpion Zinc’s EMP and EMS requirements.

3.1.9.3 Skorpion Zinc Employee Family Accommodation in Rosh Pinah

The Skorpion Zinc employee accommodation in Rosh Pinah has walls that were built with hollow Styrofoam blocks that were filled with cement reinforced with rebar. The walls have been plastered and painted in the usual way. Besides being a cost effective way of building, polystyrene is an excellent insulator against external climatic conditions. A central evaporative cooling system provides ventilation to all the rooms in the house. Toilets have been fitted with double lever flush systems.
4 DESCRIPTION OF THE ENVIRONMENT

A comprehensive description of the environment at Skorpion Zinc and Rosh Pinah has already been documented in the Skorpion Zinc Environmental Assessment (EA) (1998), Skorpion Zinc Project EA Addendum and Skorpion Zinc Refinery Sulphide Conversion Amendment to EIA Report (2015). In addition, data for the area has been captured in other EA reports that have been written for the Temporary Water Supply Pipeline, the Site Selection Study for the Rosh Pinah Landfill and in the EMPs written for NamPower’s 400kV power line construction and NamWater’s water supply pipeline for Skorpion. All these documents are lodged with Department of Environmental Affairs at the Ministry of Environment and Tourism and should be referred to in conjunction with this document.

Provision for the rehabilitation and closure of the Skorpion Zinc mine and refinery was made in the figures of the original Reunion Mining feasibility study in 1998, was updated in the final Skorpion Project feasibility study completed for Anglo American in 2000 and has been updated again as part of the Skorpion Zinc Refinery Sulphide Conversion Amendment to EIA Report (2015).

5 FINANCIAL PROVISION

Skorpion Zinc commissioned Anglo Technical Division (ATD) in 2006, to compile its mine closure plan by using the AAPlc Mine Closure Toolbox. In July 2007, the ATD generated a comprehensive Preliminary Mine Closure Plan document together with a strategy for Skorpion to achieve the various requirements related to a Detailed Draft Mine Closure Plan by 2010 (6 years prior to closure). The primary focus of this exercise was to estimate the cost of social, physical and biological closure of the operation including the Skorpion portion of the Rosh Pinah town and associated facilities/structures outside the lease areas.

Based on the current mine planning, the mine will probably be closed by the end of 2019. In May 2010, Skorpion Zinc commissioned GCS Namibia to upgrade the Preliminary Mine Closure Plan to a Final Draft Mine Closure Plan. This Plan is now in the process of being upgraded to a Final Mine Closure Plan in 2015.

This document will be provided to all relevant authorities and stakeholders upon completion.
6 LEGAL FRAMEWORK

The legislative and regulatory foundation for protection and management of the environment and its natural resources is governed by the Namibian Constitution. Article 95(1), clearly emphasizes the promotion of the welfare of the people, whereby the maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and in particular, future. This has translated into the promulgation of a number of acts that are binding to environmental management as development comes into play.


Other sector policies and legislation addressed in this chapter relate to activities and actions associated with the project and specific sections are highlighted to demonstrate relevance.

6.1 Relevant Regulatory Agencies

The regulatory agencies guarding or implementing the relevant environmental regulations are listed as follows:

<table>
<thead>
<tr>
<th>Regulating Agency</th>
<th>Role in Regulating Environmental Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Environment and Tourism (MET)</td>
<td>MET is the lead government agency charged with Environmental Monitoring, Assessment and Management. The mission of MET is to maintain and rehabilitate essential ecological processes and life-supported systems, to conserve biological diversity and to ensure that the utilization of natural resources is sustainable for the benefit of all Namibians, both present and future, as well as the international community, as provided for in the Constitution. MET lays a foundation to implementation and promulgation of regulations relevant to this project including; the Environmental Act no7. Of 2007, Park and Wildlife Management Bill, the Pollution Control and Waste Management Act, The MET plays the role in approval of Environmental Impact Assessments (EIAs) which are prepared under Environmental Assessment Policy for Sustainable Development and Environmental Conservation (1995). Provisions in other line ministries' legislation strengthens MET’s position.</td>
</tr>
<tr>
<td>Ministry of Mines and Energy (MME)</td>
<td>The MME issues prospecting and mining licences as well as exploration/prospecting and production licences ensuring that mining activities in Namibia are environmentally sustainable.</td>
</tr>
<tr>
<td>Ministry of Agriculture, Water and Forestry (MAWF)</td>
<td>MAWF’s is the leading agency undertaking the Agricultural, Water and Forestry sectors towards the promotion of an efficient and sustainable socio-economic development of Namibia. MAWF is the regulating body of the promulgation of the Water Resource Management Act, 2004 and the Forest Act 12 of 2001, relevant to this project. The Department of Water Affairs is the government agency responsible for water quality monitoring and reporting.</td>
</tr>
</tbody>
</table>
The Ministry of Works, Transport and Communication is dedicated to ensuring the availability and the quality and maintenance of transport infrastructure and specialised services. This government body is responsible for implementation of the Roads Authority Act 17 of 1999 and of relevance will be transportation of waste.

MOL is aimed at ensuring harmonious labour relations through promoting social justice, occupational health and safety and enhanced labour market services for the benefit of all Namibians. This ministry insures effective implementation of the Labour Act no. 2007 and the regulation of Health and Safety Regulations of 1992.

6.2 Policies, Plans and Legal Requirements

6.2.1 Environmental Management Act (EMA) (Act 7 of 2007)

The EA process in Namibia is governed by the Cabinet approved EMA and its Regulations (2012). It makes it mandatory for any proposed development to be subjected to an Environmental Assessment procedure. The Act sustainable development and economic growth while safeguarding the environment in the long run. The government recognizes that EAs are key tools to further the implementation of a sound environmental policy, which strives to achieve Integrated Environmental Management (IEM).

The principles of environmental management as set out in the EMA include:

- renewable resources must be used on a sustainable basis for the benefit of present and future generations;
- community involvement in natural resources management and the sharing of benefits arising from the use of the resources, must be promoted and facilitated;
- the participation of all interested and affected parties must be promoted and decisions must take into account the interest, needs and values of interested and affected parties;
- equitable access to environmental resources must be promoted and the functional integrity of ecological systems must be taken into account to ensure the sustainability of the systems and to prevent harmful effects;
- assessments must be undertaken for activities which may have significant effects on the environment or the use of natural resources;
- sustainable development must be promoted in all aspects relating to the environment;
- Namibia’s cultural and natural heritage including, its biological diversity, must be protected and respected for the benefit of present and future generations;
- the option that provides the most benefit or causes the least damage to the environment as a whole, at a cost acceptable to society, in the long term as well as in the short term must be adopted to reduce the generation of waste and polluting substances at source;
- the reduction, re-use and recycling of waste must be promoted;
- a person who causes damage to the environment must pay the costs associated with rehabilitation of damage to the environment and to human health caused by pollution, including costs for measures as are reasonably required to be implemented to prevent further environmental damage;
- where there is sufficient evidence which establishes that there are threats of serious or irreversible damage to the environment, lack of full scientific certainty may not be used as a reason for postponing cost-effective measures to prevent environmental degradation; and
- damage to the environment must be prevented and activities which cause such damage must be reduced, limited or controlled.

### 6.2.2 Minerals Policy

The MME’s mission is to be the custodian of Namibia’s mineral and energy resources and facilitates and regulates the responsible development and sustainable utilisation of these resources for the benefit of all Namibians. MME has issued this Policy specifically addressing mining and prospecting activities in environmentally sensitive areas. The areas of particular interest are those that are gazetted as “Protected Areas”.

The objective of the Minerals Policy is to:

- Ensure compliance with national environmental policy and other relevant policies to develop a sustainable mining industry. One of the eight themes of the Policy deals with the protection of the environment and with minimising the impact of mining on the environment.

### 6.2.3 Sperrgebiet

The Sperrgebiet was proclaimed a national park following a Cabinet decision during 2004.

The vision for the Sperrgebiet National Park (SNP) is to protect, manage and sustainably develop the SNP within the context of the greater Succulent Karoo, Nama Karoo, Namib and Coastal ecosystems. The biodiversity of the Karas region is recognised as exceptional, and the protection of the unique landscapes, flora and fauna are protected as part of the Sperrgebiet National Park. This has particular relevance on the current hazardous waste management practices at Skorpion Zinc, being located in the Sperrgebiet. Management Plans will be developed for this area in the near future.

### 6.3 Relevant national legal considerations

The following table presents all relevant regulations in context to the project.

<table>
<thead>
<tr>
<th>LAW</th>
<th>ATTRIBUTES RELEVANT TO THE PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Environmental Management Act (EMA) No. 7 of 2007</td>
<td>As a guiding principle for environmental management, this Act gives effect to Article 95(l) and 91(c) of the Namibian Constitution by establishing general principles for the management of the environment and natural resources; to promote the co-ordinated and integrated management of the</td>
</tr>
</tbody>
</table>
environment; to give statutory effect to Namibia’s Environmental Assessment Policy; to enable the Minister of Environment and Tourism to give effect to Namibia’s obligations under international conventions. Part II of the EMA provides principles for environmental management as set out above, while Part VII of the EMA lists different activities that are subject to EA. Section 27 (3) and 35 (1) states that unless project proponent has an environmental clearance certificate granted by the Environmental Officer, after assessing the scope, procedures and methods for conducting the assessment, the proponent may not undertake the listed activity.

| Water Resource Management 2004 | This is the primary law that governs and oversees the management, development, protection, conservation, and use of water resources. The protection and control of groundwater is provided for in Part IX, such that, a permit is required to engage in drilling, construction, enlargement or alteration of a borehole. Water pollution control is set out in Part XI, whereby discharge of effluents or construction of treatment facility, or disposal site requires a permit. Terms and conditions for such a permit are set out in section 63. |
| The Atmospheric Pollution Prevention Ordinance of | This regulation sets out principles for the prevention of the pollution of the atmosphere and for matters incidental thereto. Part III of the Act sets out regulations pertaining to atmospheric pollution by smoke. While preventative measures for dust atmospheric pollution are outlined in Part IV, Part V outlines provisions for Atmospheric pollution by gases emitted by vehicles. |
| The Public Health Act 36 of 1919 | Section 119 of this Act prohibits the existence of a nuisance on any land owned or occupied by the developer. The term nuisance is important for the purpose of this EIA, as it is specified, where relevant in Section 122 as follows: any dung pit, slop tank, ash pit or manure heap so foul or in such a state or so constructed as to be offensive or to be injurious or dangerous to health; any area of land kept or permitted to remain in such a state as to be offensive, or liable to cause any infectious, communicable or preventable disease or injury or danger to health; or any other condition whatever which is offensive, injurious or dangerous to health. |
| Soil Conservation Act 76 of 1969 | Objectives of the Soil Conservation Act 76, 1969 are to make provision for the combating and prevention of soil erosion, and for the conservation, protection and improvement of the soil, the vegetation and the sources and resources of the water supplies. |
| The Labour Act of 2007 | Regulations applicable to waste management the Labour Act are concerned primarily with the health and safety of personnel involved with all aspects of waste handling, including waste collection, transport and disposal. The regulations related to the health and safety of employees at work (the Regulations) impose a duty of care on employers to ensure that the workplace is kept free of possible adverse health effects as far as is reasonably practical. Employers should evaluate hazards to which their employees are exposed, take practicable steps to prevent the hazards from occurring, mitigate the extent of the hazard and train employees to understand the hazard and how to deal with it. The regulations under chapter 3 of this Act address the cleanliness of premises. Under this section of the regulations, any waste or waste storage area that may constitute a public nuisance shall be treated or disposed of without delay. |
| Parks and Wildlife Management Bill, 2001 | This bill gives effect to Article 95 (l) of the Namibian Constitution by establishing a legal framework to provide for and promote the conservation of wildlife and wildlife habitats, and the harmonious and
6.3.1 *International Conventions*

Namibia is a signatory to a number of international conventions. Of particular relevance to hazardous waste management are the Basel and Lome conventions, which regulate the trans-boundary movement of hazardous wastes. As a signatory to these two conventions, Namibia is not permitted to export hazardous waste for treatment elsewhere or is not permitted to import hazardous wastes.

6.3.2 *The Basel Convention*

Namibia acceded to the Basel Convention in May 1995. The 1989 Basel Convention seeks to establish a global regime for the control of international trade in hazardous and other wastes as well as their eventual disposal. Of relevance to this project is the regulation of trans-boundary movement of waste. Waste generated at Skorpion Zinc should therefore be managed at the site or within the country.

6.3.3 *The Lome Convention*

The Lome Convention subjects the European Community (EC) to a blanket ban on all direct or indirect exports of hazardous and radioactive waste from the EC to the developing African, Caribbean and Pacific (ACP) countries. At the same time the ACP countries, including Namibia, are required to prohibit the direct import of such waste from the EC or any other country.

Hazardous waste is defined so as to cover the categories of products listed in the Annexure to the Basel Convention.

6.3.4 *Convention on Biological Diversity*

The primary goal of the Convention on Biological Diversity, 1992, is the conservation of biodiversity. The causes of threats to biodiversity should be anticipated and prevented, and the precautionary principle should be applied. Parties to the convention are obliged to:

- Establish a network of protected areas;
• Create buffer areas adjacent to these protected areas using environmentally sound and sustainable development practices; and
• Rehabilitate degraded habitats and populations of species.

6.3.5 **Convention on Combat Desertification (CCD)**
The convention recognized that the conservation of biological diversity is "a common concern of humankind" and is an integral part of the development process. The agreement covers all ecosystems, species, and genetic resources. It links traditional conservation efforts to the economic goal of using biological resources sustainably. It sets principles for the fair and equitable sharing of the benefits arising from the use of genetic resources, notably those destined for commercial use.

The objectives of the CCD are:
• The conservation of biological diversity,
• The sustainable use of its components, and
• The fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

Conservation of species and ecosystem to combat the increasing rate of loss of biological diversity is one of Namibia’s challenges due to a heavy reliance on natural resources and ecosystem goods and services. In the interest of welfare of the people, the state has adopted policies aimed at maintaining ecosystems, ecological processes and biodiversity for the benefit of present and future generations. The National Biodiversity Strategy and Action Plan (NBSAP) articulate commitment of the conservation, management and sustainable use of biodiversity. Concerns with regard to biodiversity within National Parks are the disturbance of land and the destruction of habitats. Direct impact on biodiversity is predicted but precautionary approaches are necessary to ensure that disturbance impacts are avoided and are as minimal as possible.

6.3.6 **Sperrgebiet National Park**
The Sperrgebiet National Park at present is being investigated by MET and management plans for the Sperrgebiet National Park are being drafted.

6.3.7 **Skorpion EIA**
In terms of the relevant legislation, Skorpion Zinc has an approved mining license to operate the mine at Skorpion Zinc. The EIA / EMP is detailed in a document “Skorpion Zinc Environmental Assessment”, Vol. 1, October 1998. The approval of the environmental assessment resulted in a mining license No 108 to be issued in terms of Section 48 (4) of the Minerals Act, 1992.
7 ENVIRONMENTAL MANAGEMENT

7.1 Roles and Responsibilities for Environmental Management

In order to ensure sound environmental management, Skorpion Zinc will endeavour to ensure that each person at each level of the organisation, who may impact negatively on the environment, adopts responsibility for the protection of the environment.

The specific roles and responsibilities required by management to ensure effective implementation of the commitments outlined in the EMP and EMS is shown in the responsibility organogram for Skorpion Zinc (Figure 8.1). This responsibility organogram and the detailed descriptions of the respective roles and responsibilities will be found in the EMS manuals which will be made available on request.

The Skorpion Zinc general manager has signed this document, thereby accepting overall responsibility for the Environmental Management Plan for Skorpion.
Figure 7-1: Draft Organogram for Operations showing the possible structure that will be established to manage the EMP and EMS

- **ExCo**
  - Tasks:
    - Feedback to Steering Committee
    - Provide Resources/Commitment
    - Management Review

- **Environmental Steering Committee**
  - Tasks:
    - Review Red/orange Topics (Anglo Base)
    - Track Successes/Failures
    - Continuous Improvement
    - Change Monitoring
    - Escalating Problems
    - Reporting to Exec. Committee
    - Recording by Assistant
    - Strategy Development For ExCo Approval
    - EMP Management
    - Non-Conformance Management
    - Communication to all levels

- **Dept meetings**
  - Production/section meetings
  - Tasks:
    - Ensure that information is disseminated to workforce
    - Identify training needs
    - Implement action plans
    - Report on incidents

- **Quarterly meetings**
- **Monthly meetings**
- **Weekly/daily meetings**
- **Annual EMS review**
8 FACTORS IDENTIFIED IN THE ORIGINAL EA REQUIRING MANAGEMENT OR MITIGATION

An initial ranking, as determined by interested and affected parties and the consultants, of the environmental elements/resources potentially affected by negative aspects arising from Skorpion Zinc’s operations was produced in the original EA and are summarised, in descending order, in Table 9.1 below.

Table 8-1: Ranking of environmental elements affected negatively by Skorpion Zinc in descending order of importance as determined by Leopold Matrix in the original EA in 1998

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aesthetics / visual:</td>
<td>The effect of the mine, refinery and associated infrastructure on the scenery and sense of place of the area.</td>
</tr>
<tr>
<td>Land use:</td>
<td>Areas such as the tailings impoundment, waste rock dump and open pit will impact on land use but can have some wilderness quality restored.</td>
</tr>
<tr>
<td>Fauna:</td>
<td>Smaller fauna will be affected by the advance of the pit, waste rock dump and tailings impoundment with the concurrent loss of habitat.</td>
</tr>
<tr>
<td>Health:</td>
<td>Social health issues such as STD’s and AIDS and occupational impacts such as respirable dust, zinc dust, fumes, SO$_2$, acid mist, acid burns and heat stress.</td>
</tr>
<tr>
<td>Ambient air quality:</td>
<td>Dust emissions from loading, handling, and transport of ore and waste, the waste rock dump, tailings impoundment, and dust created by vehicles will impact on the ambient air quality.</td>
</tr>
<tr>
<td>Noise:</td>
<td>Local noise on site will increase, neighbours should not be affected. Ambient noise in Rosh Pinah will increase with the increase in population.</td>
</tr>
<tr>
<td>Flora:</td>
<td>There will be a loss of flora affected by the advance of the pit, waste rock dump and tailings impoundment. Flora may also be locally affected by dust and SO$_2$ emissions.</td>
</tr>
<tr>
<td>Safety and air quality (Rosh Pinah to Aus road):</td>
<td>Increased dust emissions and concurrent dust hazard as a result of increased heavy vehicles on the road.</td>
</tr>
<tr>
<td>Local social structure:</td>
<td>Impact on Rosh Pinah through the influx of aspirant job seekers and increased village size and population.</td>
</tr>
<tr>
<td>Alteration of land &amp; biodiversity (Waste disposal facilities):</td>
<td>No formal landfill exists in Rosh Pinah and pressure on the existing system through increased volumes will be an issue. Potential quarrying of the limestone outcrop</td>
</tr>
<tr>
<td>Topography:</td>
<td>Permanent impacts on the topography will be the waste rock dump, open pit, tailings impoundment and possible limestone quarry.</td>
</tr>
<tr>
<td>Hydrology:</td>
<td>Ephemeral stream diversions will have an insignificant impact on the drainage patterns.</td>
</tr>
<tr>
<td>Land owners and future land use:</td>
<td>Land values may be affected by the servitudes for major infrastructure built across neighbouring farms.</td>
</tr>
</tbody>
</table>
Potential positive impacts that Skorpion Zinc could have on the environment were also identified. These are all linked to socio-economic benefits and include increased employment opportunities, on-the-job training, increased spending power, and economic knock-on effects felt locally in Rosh Pinah. The positive impacts of the project on the regional economy and employment levels will be smaller and less significant than the local effects, but in a country with high unemployment levels and a low economic base, any contribution will be significant. Skorpion Zinc will have a positive impact on the GDP of the country.

The EA Addendum identified an increase in the potential negative impacts on flora and fauna as a result of the greater loss of sensitive habitat by the repositioning of the tailings impoundment and waste rock dump, and the increased size of the sulphuric acid plant and consequent increase in SO\textsubscript{2} emissions (although still within World Bank requirements during normal operating conditions). Additional archaeological sites were also to be impacted as a result of the change in the layout.

The Skorpion Zinc Refinery Sulphide Conversion Amendment to EIA Report (2015) identified three potential impacts as a result of the modifications to the refinery:

- Impact on air quality, human and animal health and vegetation: Since the new acid plant is a metallurgical acid plant (acid from roaster off gas) and not sulphur burning, the main sources of SO\textsubscript{2} is from vehicular emissions and the combustion of coal during industrial processes. Annual average plume maps indicate emissions associated with the new acid plant will predominantly disperse towards the northwest, illustrating that emissions from the acid plant are highly unlikely to impact on Rosh Pinah. The study found no exceedances of PM\textsubscript{10} levels but fugitive dust is an existing problem associated with the mining operations.

- Impact on groundwater and soils: Residues from the ferrite leach sample indicated a high acid potential that would have the potential to generate acid mine drainage
• Impact on the socio-economic environment: The project is expected to make several positive contributions to the local economy of Rosh Pinah, the Karas Region and Namibia and cumulatively, will contribute to Namibia reaching its Vision 2030 goals. However, some negative impacts such as the expected influx of people to town are anticipated.

Recommendations concerning operations, made in the documents listed, are incorporated in Section 12 under the relevant environmental aspect. Please note that many of the recommendations have already been incorporated into the design, or construction phase of the project, and that certain recommendations may be omitted, as experience gained during the implementation of the Construction EMP has shown that they are impractical or inappropriate.

9 EMS ENVIRONMENTAL ASPECTS DEFINITIONS AND EMS ASPECTS REGISTERS

Skorpion Zinc has implemented an environmental management system (EMS) to satisfy the requirements of the international standard for environmental management, ISO14001. This EMS will cover all operations associated with the project and has been extended to include the accommodation areas in Rosh Pinah and the storage facilities at the port in Luderitz. The EMS will act as the means by which Skorpion Zinc delivers on environmental commitments including, in particular, those detailed in the relevant environmental regulations, the EMP, Skorpion Zinc policy and other associated documents.

A key component Skorpion Zinc’s EMS is the commitment to continued improvement. By adopting this approach it is Skorpion Zinc’s intention to achieve levels of environmental performance that exceed those which could be achieved through traditional enforcement and regulation.

In order to obtain and maintain an ISO 14001 accredited EMS, Skorpion Zinc will be subjected to regular 3rd party audits. These audits will be undertaken by an internationally recognised company that complies with the requirements of the international standards for accreditation laid down by the International Accreditation Federation.

It is Skorpion Zinc’s intention to communicate openly with interested and affected parties regarding the mine and refinery’s environmental performance. All the details of the EMS will be open to the regulatory agencies on request.
9.1 The EMS Implementation Approach

Implementation of Skorpion Zinc’s EMS followed the process in the ISO 14001 standards (Figure 10.1). Skorpion Zinc has developed an environmental policy (Section 11), which outlines their commitments to environmental management. The different departmental management teams have listed, and examined, the various departmental activities that give rise to different environmental aspects as shown in Table 10.1 (e.g. atmospheric emissions and generation of solid waste), and which have the potential to impact on various environmental resources (e.g. flora, surface water etc).

An assessment of each of the aspects was undertaken and significant aspects were captured on the aspect registers. Individual aspect registers were compiled for each operational area, including the village in Rosh Pinah and the warehouse at Luderitz. Table 10.2 shows the summarised aspects registers (significant only) for Skorpion Zinc. In each area, the responsible departmental management team has compiled action plans (an example is shown in Table 10.3) to ensure effective management of each activity that gives rise to significant aspects. The entire process of aspect identification, significance rating and the development of action plans is repeatable and auditable. The process is governed by a set of procedures and the results are documented.

**Figure 9-1: The Structure of an Environmental Management System (ISO 14001)**
## Table 19-1: Pre-defined Environmental Aspects List used as part of the EMS

<table>
<thead>
<tr>
<th>Environmental Aspects</th>
<th>Explanation</th>
<th>Potential Direct and Indirect Impacts that can affect the Environment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions to Air (excluding dust, SO₂ and smell)</td>
<td>All releases to atmosphere. Includes point source emissions for example from process stacks, exhausts, leaks from pipe work and also fugitive emissions.</td>
<td>Atmosphere; flora/fauna; land potential; quality of life (humans) aesthetics/landscape; resources; soils;</td>
</tr>
<tr>
<td>Dust</td>
<td>Self-explanatory</td>
<td>Flora/fauna; soils; land potential aesthetics/landscape; resources</td>
</tr>
<tr>
<td>SO₂ Emissions</td>
<td>Self-explanatory</td>
<td>Flora/fauna; soils; land potential aesthetics/landscape; surface water resources;</td>
</tr>
<tr>
<td>Emissions to Land (solid non-hazardous waste)</td>
<td>Production and disposal (either appropriately e.g. registered landfill, or inappropriately e.g. dumping, litter)</td>
<td>Soil, groundwater, surface water, land potential, archaeology, flora/fauna quality of life (humans); aesthetics/landscape; resources;</td>
</tr>
<tr>
<td>Emissions to Land (hazardous waste)</td>
<td>• Production and disposal by landfill or dumping, of hazardous wastes, which include oils, chemicals, batteries, fluorescent tubes. • Accidental release of hazardous materials (e.g. oils, chemicals) to ground</td>
<td>Flora/fauna; soils; land potential aesthetics/landscape, archaeology, quality of life (humans); resources</td>
</tr>
<tr>
<td>Emissions to Water (domestic)</td>
<td>Release to sewer, surface water or groundwater from activities of a domestic nature (including laundry, cleaning, irrigation)</td>
<td>Flora/fauna; resources; quality of life (humans); groundwater, surface water; soils</td>
</tr>
<tr>
<td>Emissions to Water (industrial)</td>
<td>Release to sewer, surface water or groundwater from an industrial activity</td>
<td>Flora/fauna; resources; quality of life (humans); groundwater, surface water</td>
</tr>
<tr>
<td>Local Noise</td>
<td>Self-explanatory</td>
<td>Fauna; quality of life (humans)</td>
</tr>
<tr>
<td>Remote Noise</td>
<td>Self-explanatory</td>
<td>Fauna; aesthetics/landscape, quality of life (humans)</td>
</tr>
<tr>
<td>Energy Use</td>
<td>Use of any fuel to meet a power requirement Includes the use of power generated on or off site.</td>
<td>Resources</td>
</tr>
<tr>
<td>Use of Natural Resources</td>
<td>• Use of water, timber and/or other vegetable matter, animal matter, minerals (unprocessed) • Use of land</td>
<td>Soils; land use potential; resources; quality of life (humans), groundwater, surface water; archaeology</td>
</tr>
<tr>
<td>Use of Manufactured Materials</td>
<td>Use of all materials, not falling into the natural resource category (i.e. materials which have been subject to processing, for sale as manufactured items)</td>
<td>Aesthetics/landscape;</td>
</tr>
<tr>
<td>Visual Impact</td>
<td>Effect on the aesthetic quality of the environment.</td>
<td>Aesthetics/landscape, land potential; quality of life (humans); resources</td>
</tr>
<tr>
<td>Vibration</td>
<td>Self-explanatory</td>
<td>Fauna; quality of life (humans)</td>
</tr>
<tr>
<td>Smell</td>
<td>Self-explanatory</td>
<td>Quality of life (humans) resources – tourism</td>
</tr>
<tr>
<td>Impact on Biodiversity</td>
<td>Aspects which affect ecological features (e.g. ecosystems, habitats - including soils, individual specimens of plants and/or animals)</td>
<td>Flora/fauna; soils, land potential aesthetics/landscape, quality of life (humans); groundwater, surface water</td>
</tr>
<tr>
<td>Other</td>
<td>Any aspect not considered to fall into the</td>
<td>Archaeology</td>
</tr>
<tr>
<td>defined aspect categories</td>
<td>Emergency situation</td>
<td>Emergency conditions with potential for environmental [and human] incidents, including natural (e.g. flooding, lightning) disasters and human induced deliberate (e.g. arson) and accidental situations (e.g vehicle crash).</td>
</tr>
</tbody>
</table>
### Table 19-2: Summary Significant Aspects Register for Skorpion Zinc (June 2002)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining Technical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operations</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refinery Area 1 Comminution</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaching &amp; Neutralising</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BZS &amp; Impurity removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid Plant</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effluent treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailings impoundment</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refinery Area 2 Solvent Extract</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell house</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melting and casting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refinery Area 3 (laboratory)</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrubbers, drains, extractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refinery Conversion (Sulphide processing)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metallurgical acid plant</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roaster Plant and pre-heater</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcine handling unit, roaster plant and pre-heater</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training Plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engineering &amp; Maintenance &amp; repairs</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaning</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Workshops</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Materials Management</strong></td>
<td><strong>Storage</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lüderitz warehouse un / loading</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Human resources / admin</strong></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family accommodation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other accommodation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amenities</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 19-3: An example of the type of action plans that are developed for each operational area for all aspects that are considered significant

<table>
<thead>
<tr>
<th>AREA: MINING</th>
<th>Management Action</th>
<th>Due Date</th>
<th>Current Status</th>
<th>Responsible Person</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity:</strong> Drilling (exploration)</td>
<td><strong>Emissions to land - hazardous waste</strong></td>
<td>Provide environmental coordinator with a list of all hazardous waste generated in mining area, for inclusion in hazardous waste disposal procedure</td>
<td>21/07/02</td>
<td>Complete</td>
</tr>
<tr>
<td></td>
<td>Review and comment on Procedure XXX: Disposal of Hazardous waste.</td>
<td></td>
<td>30/07/02</td>
<td>In progress</td>
</tr>
<tr>
<td></td>
<td>Dispose of hazardous waste (used oils, tyres etc) as specified in Procedure XXX</td>
<td></td>
<td>15/08/02</td>
<td>Being implemented</td>
</tr>
<tr>
<td><strong>Activity:</strong> Loading &amp; hauling</td>
<td><strong>Emissions to land - hazardous waste</strong></td>
<td>Review and comment on Procedure XXX: Disposal of Hazardous waste.</td>
<td>30/07/02</td>
<td>Completed</td>
</tr>
<tr>
<td><strong>Energy consumption</strong></td>
<td>Ensure efficient consumption of fuel by constantly monitoring fuel consumption (An electronic fuel monitoring system has been installed)</td>
<td></td>
<td></td>
<td>Implemented</td>
</tr>
<tr>
<td><strong>Dust management</strong></td>
<td>Ensure that dust suppression is being enforced on haul roads.</td>
<td></td>
<td>Ongoing</td>
<td>Implemented</td>
</tr>
<tr>
<td><strong>Activity:</strong> Dust suppression</td>
<td><strong>Use of natural resources</strong></td>
<td>Optimization of water-bowser spray mechanism through monitoring distribution and pattern of water.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water consumption by water-bowser truck is to be monitored during the first year of operations. These figures are to be used later as reference data.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Activity:</strong> Active dumps advance &amp; ore stockpiles</td>
<td><strong>Visual impact</strong></td>
<td>Remediation will be undertaken throughout the life of the mine to ensure that visual impact is minimized</td>
<td>30/06/03</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Biodiversity</strong></td>
<td>Removal of plants</td>
<td>When constructing new haul roads in areas that have previously not been disturbed, inform the environmental department at last two weeks prior to the commencement of construction so that if required plants can be removed.</td>
<td></td>
<td>Implemented</td>
</tr>
<tr>
<td><strong>Emergency situations</strong></td>
<td>Spillage - fuel or oil</td>
<td>Review Procedure XXX - Spillage of hazardous liquids (diesel, petrol, and oils) to ensure that all issues relating to heavy</td>
<td>30/07/02</td>
<td>Not yet implemented</td>
</tr>
</tbody>
</table>
### AREA: MINING

<table>
<thead>
<tr>
<th>Significant aspect</th>
<th>Management Action</th>
<th>Due Date</th>
<th>Current Status</th>
<th>Responsible Person</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity</strong></td>
<td>Drilling (exploration)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>vehicles are covered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Activity:</strong> Mining vehicles workshop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions to land- solid non hazardous waste</td>
<td>Dispose of non hazardous waste as per Procedure XXX – Management and disposal of non hazardous waste.</td>
<td>Ongoing</td>
<td>Implemented</td>
<td>Area Engineer</td>
</tr>
<tr>
<td></td>
<td>Conduct regular inspections to assess level of commitment by workshop personnel to separation of non hazardous waste.</td>
<td>Ongoing</td>
<td>Implemented</td>
<td>Safety officer Mining &amp; Environment al coordinator</td>
</tr>
<tr>
<td><strong>Activity:</strong> Main Mining admin building</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy consumption</td>
<td>Establish an electricity monitoring programme for the mining complex. (Liaise with Engineering department).</td>
<td>30/11/02</td>
<td>In progress</td>
<td>Area Engineer</td>
</tr>
</tbody>
</table>

### 10 OVERARCHING EMP COMMITMENTS

There are several overarching commitments that Skorpion Zinc has made in order to be compliant with the requirements of the Mining Licence and Environmental Contract. These are listed below.

- Skorpion Zinc will establish and communicate an environmental policy that outlines the mine and refinery’s commitment to sound environmental management.
- Establish and maintain an Environmental Management System (EMS) that meets the ISO 14001 requirements. The establishment of such an EMS implies that all environmental risks will be identified on an ongoing basis and that action plans will be put in place to address the risks that are identified. The ISO standard requires that monitoring, auditing and continual improvement of the EMS be also undertaken.
- Skorpion Zinc commits itself to meeting all the applicable legal requirements of the government of Namibia and all the international conventions and policies to which Namibia is a signatory. In addition, compliance with the World Bank Standards that were stipulated in the Environmental Assessment (1998) and the EA Addendum (2000) will be met. Where no Namibian legislation or World Bank Standards exist, Skorpion may determine and may choose to apply the most suitable best practice that is relevant and applicable for the southern African context.
- Skorpion Zinc will establish a communications system by which all interested and affected parties may communicate their concerns or comment on issues regarding
Skorpion Zinc’s activities and receive in return a reasonable response from Skorpion Zinc’s management.

- All Skorpion employees, partners, service suppliers, contractors and any other visitors to Skorpion Zinc will be inducted on, and expected to adhere to, the principles laid out in the Environmental Policy (and other policies), or to any operational systems or procedures such as waste management and incident reporting, amongst others.
- A system will be established in which all environmental incidents are reported and investigated.
- Emergency response procedures will be written and communicated for all activities that have been identified as significant environmental risks. These will be reviewed and modified annually.

The Skorpion Zinc Environmental Policy is presented on the following page. This policy may be considered the equivalent of the Environmental Code of Conduct required by the EMP guidelines.
Skorpion Zinc Environmental Policy

Skorpion Zinc extracts and processes Zinc from an ore body in a remote area of Southern Namibia. The site is located adjacent to a transfrontier conservation area - a part of Namibia recognised as one of the World’s 25 biodiversity hot spots. This is a fragile and special environment and we recognise our responsibility to act in a way that preserves this unique eco-system.

Our ambition is to become the World's preferred supplier of quality zinc.

We acknowledge that our operations have environmental, social and economic impacts and are committed to the implementation of a management system, and promotion of a company culture, which addresses significant issues in all of these areas.

**Aims:**

In particular we will:

- Communicate openly with local communities and those other communities on which we depend. We will seek to build positive and constructive relationships that enhance capacity of all parties.
- Commit to continual improvement in our environmental performance and wherever possible prevention of pollution arising from our operations.
- Commit, in all our operations, to comply as a minimum with all relevant legal requirements. In addition we will comply with, or exceed, the additional requirements of our parent company, Anglo American, and strive to achieve or set industry best practice wherever possible.
- Identify and implement controls that will minimise dust and other significant atmospheric releases associated with our activities.
- Avoid, and where this is not possible, minimise adverse impacts on the unique ecological and landscape features of the region.
- Minimise wastes from our operations and seek to avoid the use of, substitute, reuse, recycle and/or recover materials wherever practicable.
- Manage water use in a way that conserves this scarce resource by minimising water consumption and pollution of water resources.
- Plan, implement and monitor the effects of a land rehabilitation program, focused on long term environmental protection and restoration.

**Management Principles:**

- Work with our partners (i.e. suppliers of goods and services) to manage our collective environmental impact.
- Engage all of our personnel in achieving our objectives and acknowledge the value of their contributions.
- Educate our employees in a way that provides life skills, recognised qualifications and the training needed to work in an environmentally responsible way.
- Work with other companies operating locally and the Skorpion families to promote co-operation and continual improvement in the quality of life of the local community.
- Engage in dialogue with local, regional and national bodies with a view to sharing experience in the field of environmental protection and management and working towards a shared goal of continual improvement in environmental quality.
- Periodically evaluate all of our activities to identify significant environmental, and social issues. We will put in place management action plans for all significant issues and set targets in key areas. Progress towards these targets will be monitored and reported regularly.

This policy applies to all activities of the Skorpion Zinc including the operations at Luderitz and the accommodation areas set aside for Skorpion personnel and their families in the nearby town of Rosh Pinah.
11 EMP OBJECTIVES AND ACTIONS BY SIGNIFICANT ASPECTS

This section describes the specific environmental aspects arising from Skorpion Zinc’s activities. Management objectives to which Skorpion Zinc will commit are outlined for each aspect, and the general mitigation measures required in order to meet these objectives are documented. These management objectives will be reviewed throughout the life of the mine as an integral part of the EMS in order to ensure relevancy and continual improvement.

The legal requirements to which Skorpion Zinc is obliged to commit, as a minimum, are included in the legal register - a stand-alone document that will be updated annually to reflect changes in Namibian legislation. In addition, a brief description of the laws associated with each aspect is also included under the relevant section of the EMP.

The management commitments listed under each aspect are all auditable and can be used to check compliance. This can be achieved by asking whether the commitment has been implemented or not. Alternatively, the level of implementation of the specific commitment can be marked as complete (C), adequate (A) or inadequate (I), which is the same system as was used for the monitoring of compliance for the Skorpion Zinc Construction EMP.

For each aspect that is discussed in Section 12 of this EMP, there is a list that gives examples of the performance indicators or documents that can be used during an audit to determine compliance to, and/or measure performance of, the management commitments stated in the EMP. Although some examples are given, it must be noted that these lists are neither complete or a definitive list of the types of documents that may be available and can be subject to change throughout the life of the mine.

If an aspect is listed as significant on a department’s aspects register, then ISO 14001 requires that actions be taken to manage that particular aspect. Compliance with the commitments can thus also be checked through the EMS aspects registers and action plans.

The ISO 14001 standard requires that the aspects registers are reviewed annually. There are therefore few time-specific management commitments because the annual review is implicit.
11.1 Aspect - Emissions to Air (all except dust and SO$_2$)

11.1.1 Background
The quality of the air over Skorpion Zinc is generally very clear and clean, except for the high levels of natural dust during strong berg wind episodes. The area is sparsely populated, there is barely any grassland or woody vegetation for fires, and there is only minor/light industrial activity at the village of Rosh Pinah. The local air quality can therefore be considered excellent, except during very windy episodes. Skorpion Zinc acknowledges the privilege of the unpolluted air where it operates. In return, Skorpion Zinc commits to attempt to reduce or eliminate emissions that negatively impact on air quality.

Emissions to air, other than dust and SO$_2$ include exhaust emissions, acid mists, organic fumes, water vapour, point source emissions from certain stacks or towers, possible leaks from pipe work and fugitive emissions. Small quantities of NOx gases may also be emitted during acid plant start-ups and associated with the roaster plant and pre-heater, however this is likely to be well within World Bank limits and will not be monitored.

The combined effects of these emissions could impact on the sensitive desert vegetation surrounding the mine and refinery and on the quality of life of employees or nearby residents. Therefore Skorpion Zinc has committed itself, in its environmental policy, to reduce, as far as is possible, significant atmospheric releases associated with its activities.

11.1.2 Legal requirements
There are no Namibian minimum requirements for ambient air quality. However, the World Bank Ambient Air Quality Standards were adopted for Skorpion Zinc and are to be found in the legal register and Appendix C. Any changes to legislation will be reflected in the legal register.

11.1.3 Goals and objectives
Monitor and manage the potential negative impacts associated with atmospheric emissions arising from Skorpion Zinc’s activities.

11.1.4 Management commitments for all emissions except dust and SO$_2$

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skorpion Zinc will identify the specific mine, refinery and supporting activities that release emissions (point source and fugitive) and determine the environmental risk associated with these emissions.</td>
<td></td>
</tr>
<tr>
<td>Identify cost effective and practical ways by which to reduce risky emissions.</td>
<td></td>
</tr>
</tbody>
</table>
11.1.5 Performance indicators and documentation for measuring compliance to commitments

The EMS action plans and minutes of the various EMS review meetings can be reviewed to determine what action has been taken for activities identified as significant risks.

Equipment maintenance records will provide information on how regularly equipment is maintained.

Emissions monitoring equipment maintenance logs for the various parts of the refinery may be examined.

The records kept for occupational health can be checked.

Any emissions of gasses can be checked by observing stacks and exhausts.

Certain emissions can also be smelt.

11.2 Aspect - Emissions to Air (dust)

11.2.1 Background

Skorpion Zinc is situated in a virtually pristine arid area characterised by very low rainfall, high evaporation rates and strong winds. Dust is one of the most significant emissions that Skorpion Zinc will produce. Sources of dust include:

- The pit and ore stockpiles (rock and ore handling),
- Tailings impoundment,
- Waste rock dump,
- Topsoil stockpile area,
- Disturbed areas (removal of the fragile layer of soil on the desert “pavement”, which, once destroyed, causes the underlying soil to become susceptible to wind erosion), and
- Haul roads and national road (particulate entrainment by vehicles).

During consultation with the directly affected I&As regarding the proposed Refinery Conversion project, it became evident that dust particularly as a result of the mining operations, TSF and haul roads, is a particular concern. The dust emission impact is expected to be less for both mining and tails once the refinery conversion process is implemented. However, Skorpion Zinc runs a dust management program, which includes a network of dust fallout samplers. Management recognise that fugitive dust fallout rates along the downwind fenceline of the mine property are sometimes above the suggested industrial guideline. Dust nuisance abatement methods that can be considered for the tailings dam and unpaved roads are provided in Appendix C. Although the cast house
capacity will be increased from 150 to 200ktpa Zn, the bag house capacity will be upgraded for extra capacity to ensure dust control.

11.2.2 Legal requirements

There are no Namibian requirements for ambient dust emissions, however the World Bank Guidelines on Ambient Air Quality Standards were adopted for Skorpion Zinc and are listed in the legal register and Appendix C. Any changes to legislation will be reflected in the legal register.

It must be noted that ambient conditions in the vicinity of Skorpion Zinc on occasion already exceed the WB Guidelines, as the area is extremely dusty due to the prevailing climatic conditions.

11.2.3 Goals and objectives

Reduce Skorpion Zinc’s dust emissions (nuisance dust and inhalable dust fractions) generated as a result of the mine and refinery activities as far as is reasonably practical, given that the baseline data at Skorpion indicates that ambient dust levels are already high.

Monitor the ambient, environmental, and occupational dust levels.

11.2.4 Management commitments for dust

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C/A/I</td>
</tr>
<tr>
<td>Skorpion Zinc will identify the specific mine and refinery activities that create dust.</td>
<td></td>
</tr>
<tr>
<td>If any activity is identified as being a significant risk, determine what cost effective and practical ways exist in which to reduce these sources of dust.</td>
<td></td>
</tr>
<tr>
<td>Detailed action plan will then be developed in the EMS if any opportunities are identified.</td>
<td></td>
</tr>
<tr>
<td>EMS aspects registers will be reviewed annually.</td>
<td></td>
</tr>
</tbody>
</table>

Skorpion will minimise the extent of disturbed areas and only clear vegetation immediately in advance of when the area is to be worked. Dust will be controlled where practical. Disturbed areas will be rehabilitated as they become available.

11.2.5 Performance indicators and documentation for measuring compliance to commitments

- The success of dust management strategies at Skorpion Zinc can be assessed visually, although it must be remembered that the ambient dust levels are already high.
- The I&BAP register can be audited to see what complaints / compliments have been made by the public or employees.
- The dust monitoring program results can be reviewed to check compliance.
- The occupational health monitoring results can be checked.
The EMS action plans and minutes of the various EMS review meetings may be reviewed to determine what problems have been identified and what actions have been taken.

11.3 Aspect - SOx Emissions (sulphur dioxide and sulphur trioxide)

11.3.1 Background

Uncontrolled emissions of SOx gases from factories, smelters and refineries in the past have lead to the creation of acid rain that has been responsible for large-scale destruction of buildings and vegetation surrounding these sites.

With the conversion of the refinery for the processing of sulphides, some SO\textsubscript{2} emissions are expected. However, because the new acid plant is a metallurgical plant (acid from roaster off gas) and not sulphur burning the concentrations are expected to remain low. By increasing the stack height from 50m to 70m an improvement of 32% is predicted in the annual average ambient concentrations. Annual average plume maps indicate emissions associated with the new acid plant will predominantly disperse towards the northwest, which correlates to the predominant winds, which originate from the southeast; also illustrating that emissions from the acid plant are highly unlikely to impact on the nearest town (Rosh Pinah). Exceedances of the 24-hour IFC guideline are predicted at receptor R\textsubscript{NW1} (tail of overland tailings conveyor, near ROM stockpiles) at a stack height of 50 m for the new acid plant. However, when the stack height is increased to 70 m or 100 m, no exceedances are predicted at this receptor.

The sulphuric acid plant at Skorpion Zinc has been built using the most up to date technologies, and any SO\textsubscript{2} and SO\textsubscript{3} emissions will be below World Bank Guideline thresholds during normal operations. However, it is possible that SOx emissions will exceed this threshold during the acid plant start-ups and thus every precaution to ensure that start-ups are conducted effectively will be in place.

Although the formation of acid rain is usually associated with industrialised, higher rainfall regions, fog is also known to become acidic. Fog is relatively common at Skorpion and is an important supplier of moisture to the highly specialised plants and animals found in the area. It is possible that SOx emissions from Skorpion may react with the fog to produce a deposit that may impact locally on vegetation and infrastructure. The effect of such an impact is unknown as there is a lack of information on the impact of SO\textsubscript{2} on plants and animals in arid environments, and the Succulent Karoo biome in particular.

Sulphur dioxide has an unpleasant smell and can affect an individual’s quality of life if inhaled in excessive doses.
11.3.2 Legal requirements
There are no Namibian requirements for ambient SO2 and SO3 levels, however the World Bank Ambient Air Quality Standards were adopted for Skorpion Zinc and are listed in the legal register and Appendix C. Any changes to legislation will be reflected in the legal register.

It must be noted that Skorpion Zinc may exceed the World Bank guidelines during acid plant start up, but that every practical endeavour to avoid this will be undertaken.

11.3.3 Goals and objectives
Ensure that SOx emissions from the Skorpion refinery are kept low under all operating and start up conditions and thereby reduce possible potential negative impacts on surrounding vegetation.

Monitor SO2 emissions1.

Determine whether SO2 impacts negatively on the surrounding vegetation. Manage accordingly.

11.3.4 Management commitments for SOx emissions

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endeavour to keep SO2 emissions at a level below the World Bank Guidelines threshold during normal operations and start-ups.</td>
<td></td>
</tr>
<tr>
<td>Endeavour to undertake acid plant start-ups when there is no fog, and ensure that abnormal operating conditions do not persist for extended periods of time.</td>
<td></td>
</tr>
<tr>
<td>Install a comprehensive SO2 monitoring program that will record real time emissions and model the geographic range of SO2 emissions. The program will be reviewed regularly.</td>
<td></td>
</tr>
<tr>
<td>Monitor occupational health exposure.</td>
<td></td>
</tr>
<tr>
<td>Initiate studies to determine the possible effects of SO2 on Succulent Karoo vegetation.</td>
<td></td>
</tr>
</tbody>
</table>

11.3.5 Performance indicators and documentation for measuring compliance to commitments

- The I&AP register can be audited to see what complaints / compliments have been made by the public or employees.
- The EMS action plans and minutes of the various EMS review meetings can be reviewed to determine what opportunities have been identified and what actions have been taken.
- The SO2 atmospheric monitoring program results will be available for review.
- The SO2 and dust vegetation monitoring program results will be available for review.

1 It has been assumed that the monitoring and the management of SO2 levels will directly impact on the levels of SO3 produced and therefore monitoring of SO3 is not necessary, particularly as SO3 is very unstable in the atmosphere and consequently extremely difficult to measure.
• The occupational health monitoring results may be checked.
• All SHE (Safety, Health and Environment) incidents will be recorded and reported upon and these records may be checked.
• The internal and external EMS audit results and reports can be reviewed.

11.4 Aspect - Emissions to Land (solid non-hazardous waste)

11.4.1 Background

Around the world the disposal of industrial and domestic waste is becoming an expensive process. Not only are large volumes of potential usable material being discarded, but also the cost of storing the waste volumes involved is steadily increasing as competition for land increases. At Skorpion the major non-hazardous waste streams include waste rock from the pit, residue filter cake (tailings) from the refinery, evaporation ponds and oil separation systems, and all general waste generated at the offices, workshops and Skorpion Zinc employee houses. Non-hazardous wastes have the potential to pollute soils and water, and cause harm to animals and vegetation. Management risks include the potential risk to human health and safety (e.g. dump failure).

During the 1998 EIA it was concluded that the oxidised secondary zinc deposit contains no sulphide minerals that could contribute to groundwater pollution. This meant that neither the pit, nor the waste rock dumps would be acid generating.

However, with the proposed modifications to the Refinery Plant an updated waste characterization study was undertaken to determine the net acid generating potential of the materials as well as any potential metals that could be contained in the residues. The sample from the calcine leach residue showed a higher acid potential than neutralization potential. It is therefore only residues from the calcine leach circuit that would have the potential to generate acid mine drainage. By neutralizing the calcine leach residue with limestone in a ratio of 1:3 the leach can be declassified as hazardous waste and can therefore be disposed of on the existing tailings dam. The blend ratio of 1:2 reduces metal concentrations in seepage from residue material. A limestone blend ratio of 1:1 (1 part limestone to neutralise 1 part calcine leach residue dry basis) would minimize any potential contamination impact. It is therefore recommended to neutralise the calcine leach residue with limestone (1:1 ratio) before safe co-disposal onto the current unlined tailings facility.

To ensure the stability of this blend, a continued geochemical testing will be done.

Disposal of general waste will be to landfill. Skorpion Zinc currently dispose general waste in a temporary landfill located within the footprint of the waste rock dump, but will use the municipal landfill in Rosh Pinah once it has been constructed.

Waste rock will go to the waste rock dump whilst goethite (non-hazardous waste) and the neutralised calcine leach residue will go to the tailings impoundment.
11.4.2 Legal requirements
The Minerals Act, No 33 of 1992 for Namibia requires details regarding pollution control and waste management. See Appendix C and the legal register that will reflect any changes to legislation.

11.4.3 Goals and objectives
Adopt a practical approach to waste management that will, as far as possible, minimise the amount of waste generated and manage it according to the "four R principle", namely recover, reduce, recycle and reuse.

Ensure that the waste that is generated is disposed of in a safe and environmentally acceptable manner and in a way that does not pollute water resources, create excessive dust or leave behind a significant visual impact.

11.4.4 Management commitments for solid non-hazardous waste to land

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A comprehensive waste management system in which all non-hazardous solid waste issues are addressed will be developed.</td>
<td></td>
</tr>
<tr>
<td>• This system will be reviewed on an annual basis and practical and cost effective action plans will be developed to address opportunities for improvement.</td>
<td></td>
</tr>
<tr>
<td>• The detailed action plans will be recorded in the EMS.</td>
<td></td>
</tr>
<tr>
<td>• A recycling programme for general office and household domestic waste will be established in which recyclable materials are sorted at source from putrecibles and non-recyclable materials (general waste).</td>
<td></td>
</tr>
<tr>
<td>• The recyclable waste streams will be stored until such time as they can be sent to a recycle depot.</td>
<td></td>
</tr>
<tr>
<td>• General waste will be disposed of at a managed landfill. In the short term this will continue to be the landfill on site. In the long term it will be to the domestic landfill in Rosh Pinah.</td>
<td></td>
</tr>
<tr>
<td>• As far as is possible, all suppliers will be required to take back packaging, drums, pallets, containers etc.</td>
<td></td>
</tr>
<tr>
<td>• Those that cannot be taken back by suppliers will be recycled, reused or land filled where appropriate and according to the waste management system (see Appendix A).</td>
<td></td>
</tr>
<tr>
<td>• Waste rock and residue filter cake (tailings) will be disposed of correctly in the designated sites in a manner that reduces the risks of failure of the dump/impoundment, dust emissions and/or possible pollution of soils and ground water.</td>
<td></td>
</tr>
</tbody>
</table>

11.4.5 Performance indicators and documentation for measuring compliance to commitments
• A visual inspection may be undertaken to determine if the waste management and recycling system is operational.
• All SHE incidents will be recorded and reported upon and these records may be checked.
The internal and external EMS audit results and reports can be reviewed.

Soil and water pollution monitoring results can be checked, although groundwater monitoring is not expected to be undertaken until later during the life of mine.

The various purchasing contracts with suppliers can be checked to determine if efforts to return containers have been explored.

Any inspection reports completed for the tailings impoundment may be reviewed.

The recycle depot will maintain records of volumes of materials that are recycled.

The EMS action plans and minutes of the various EMS review meetings can be reviewed to determine what action has been taken for activities identified as significant risks.

11.5 Aspect - Emissions to Land, Water and Air (Hazardous Waste)

11.5.1 Background

Hazardous waste has the potential to affect human and/or environmental health. This is because of the inherent chemical and physical composition that could be toxic, poisonous, flammable, explosive, carcinogenic or radioactive.

The accidental, negligent or deliberate spillage or inappropriate disposal of hazardous substances could result in air, soil and water pollution and may affect the health and wellbeing of people, fauna and flora.

Essentially the hazardous waste streams at Skorpion Zinc can be classified into the following three major groups:

1. All waste disposed at the tailings dam:
   a. Crud;
   b. ETP cake;
   c. Manganese dioxide; and
   d. Spent carbon.
   e. Filtered sulphur waste

2. Other hazardous waste:
   a. E-waste;
   b. Fluorescent tubes;
   c. Office waste (printer cartridges etc.)
   d. Laboratory waste;
   e. Hydrocarbons; and
   f. Other stored chemical waste.

3. Vanadium pentoxide.

Metals associated with the calcine leach residue will decrease significantly when adding limestone in a ratio of 1:2. This, coupled with a pH of 7 to 7.6, will remove the chemicals of concern through precipitation. Skorpion Zinc is committed to neutralize the calcine leach
residue in ratio of 1:1 to eliminate any potential contamination impact and is therefore recommended for safe co-disposal.

11.5.1.1 Tailings dam

The Crud, Manganese dioxide, spent carbon and ETP Cake is classed as Hazardous Waste according to the waste classification systems. In order for Skorpion Zinc to continue with the current disposal of this waste at the tailings dam, Skorpion Zinc has implemented a monitoring system to determine impact the environment and / or on human health.

The Crud, Manganese oxide and ETP Cake makes up 1.3% of the material deposited on the tailings dam. Due to it being fed onto the conveyor with the tailings, no planned deposition strategy is undertaken.

The Skorpion tailings contain 38-42% moisture. Even given the climatic conditions (B-), the tailings will generate some leachate. The solubility and pH dependence of certain elements has not been investigated. It is also not known how the liquid organics from the Crud and carbon will behave in the tailings dam and whether it will stay in suspension or will migrate with the leachate into the groundwater environment. The liquid organic portion of the Crud is a light non-aqueous phase liquid (LANPL) and as a result will “float” on water.

The organic portion of the Crud is a hydrocarbon which naturally decays over time.

In order to determine the risks of the disposal of the hazardous material at the tailings dam, the potential pathways (air & water) into the environment are being investigated and monitored.

Groundwater analysis of borehole BHT1 indicates active contamination of the groundwater by sulphates, chlorides and nitrates and some organics. In order to comply with the waste disposal legislation, the potential impact of the current hazardous waste disposal at the tailings dam on the environment needs to be quantified.

Three dedicated monitoring boreholes were drilled around the tailings dam to monitor the potential migration of contamination from the tailings dam into the groundwater environment.

11.5.1.2 Other hazardous waste

All other hazardous waste (fluorescent tubes, laboratory waste, E-waste, oil and greases, and chemicals) will be transported to the Walvis Bay H:h site. All required negotiations with the Walvis Bay H:h site have been completed and the necessary transport permits obtained from the relevant authority (refer to Appendix B). The stored laboratory waste, E-waste, oil and greases plus chemicals can be disposed of at the Walvis Bay H:h site. The municipality agreed to allow the waste to be disposed of the site pending:

- A classification of the waste;
- Volumes; and
- An agreement between Skorpion Zinc and Walvis Bay Municipality for payment.

The necessary permit has been obtained to transport the waste from Skorpion Zinc to Walvis Bay (refer to Appendix B).

11.5.1.3 Vanadium Pentoxide
The agreement reached between Skorpion Zinc and the Walvis Bay Municipality includes the disposal of Vanadium Pentoxide at the Walvis Bay H:h site.

11.5.2 Legal requirements
The Minerals Act, No 33 of 1992 for Namibia has regulations regarding pollution control and waste management. This EMP is part of the Environmental Contract required under the Minerals Act. See Appendix C and the legal register that will reflect any changes to legislation.

A permit was required from the Walvis Bay Municipality for the disposal of hazardous waste at their facility.

11.5.3 Goals and objectives
Implement all reasonable measures to prevent leakage and spillage of hazardous material and ensure that all hazardous waste is disposed of in an environmentally friendly and safe manner. Minimise the risk of hazardous substances affecting the health of individuals, plant and animal life by installing comprehensive hazardous waste management systems.

As far as possible minimise the presence hazardous waste on site and, where possible, substitute hazardous products for more environmentally friendly substitutes. Reuse, recycle and/or recover materials wherever practical.

11.5.4 Management commitments for hazardous waste

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify all hazardous materials being used in the operation. Install a comprehensive hazardous waste management system to manage the transport, storage, use and disposal of hazardous materials and their by-products (refer to Appendix A).</td>
<td></td>
</tr>
<tr>
<td>In order to determine the risks of the disposal of the hazardous material at the tailings dam, the potential pathways (air &amp; water) into the environment are being investigated and monitored.</td>
<td></td>
</tr>
</tbody>
</table>
| Groundwater - Three dedicated monitoring boreholes around the tailings dam to monitor the potential migration of contamination from the tailings dam into the groundwater environment. Monitor groundwater quality in boreholes on a monthly basis:  
  • Inorganics: pH, TDS, anions, cations and trace elements Al, Mn, Fe, Zn. | |
- Organics: Sample for LNAPLS (free product).
- Sample for dissolved organics in the groundwater.
- Analysis must include: Total Petroleum Hydrocarbons (TPH) & BTEX.

The results of the monitoring programme must be analysed after one year’s monitoring. The impact on the environment will be determined and if the impact is unacceptable, mitigation measures will have to be implemented. The impact will be measured using acceptable criteria and internationally accepted intervention levels.

<table>
<thead>
<tr>
<th>Air quality</th>
<th>Monitoring of dust in fallout buckets, PM10 and PM2.5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation and Soils</td>
<td>Vegetation and soils must be continually monitored in order to ensure that they are not being impacted through the pathways outlined above.</td>
</tr>
<tr>
<td>Emergency response procedures to include response to accidents involving hazardous materials.</td>
<td></td>
</tr>
</tbody>
</table>

Skorpion Zinc will ensure that all areas where hazardous materials are handled or stored are adequately bunded and that the bunds are well maintained.

In the event of large spills of hydrocarbon based substances (diesel petrol, oil etc) these will be bioremediated *in situ* where possible.

Smaller spills will be lifted and taken to bioremediation site for treatment.

Remove sewage sludge periodically from the sewage treatment plants at Skorpion and Rosh Pinah and dispose of it according to the permitted procedure agreed with the Department of Water Affairs of the MWARD.

Should the copper and nickel cakes produced by the refinery not be utilised or sold, they will be disposed of correctly at an appropriate facility.

Ensure that sulphur spills at the Lüderitz warehouse are disposed of in an appropriate manner.

Keep records of the disposal of all hazardous waste.

11.5.5 *Performance indicators and documentation for measuring compliance to commitments*

- Visual inspections can be carried out to check on the waste disposal systems, particularly the disposal of hazardous waste. In addition, appropriate bunding and oil spills can be checked visually.

- All SHE incidents will be recorded and reported upon and these records may be checked.

- Every area where chemicals or hazardous materials are stored and used will have Materials Safety Data Sheets available for referral.

- The EMS aspects registers and action plans pertaining to waste management in each area on the mine and refinery will be available for review.

- Emergency response procedures will be available for inspection.
- The internal and external EMS audit results and reports can be reviewed.
- The various purchasing contracts with suppliers can be checked to determine if efforts to return containers have been explored.
- The permits and monitoring results for effluent disposal can be reviewed.
- Refinery production records pertaining to nickel and copper cake can be reviewed.
- The disposal of recycled / used oils can be checked.
- Evidence for the safe disposal of any hazardous waste will be made available.
- Borehole monitoring results.
- Dust fallout, PM10 and 2.5 measurements.
- Visual inspections on the vegetation within the area.

11.6 Aspect - Emissions to Water (Domestic)

11.6.1 Background

Water is a scare resource in the Namib Desert in which Skorpion Zinc is situated. Skorpion has committed itself to various water saving measures in both the mine and refinery and at the employee accommodation in Rosh Pinah.

Mine and refinery activities such as laundry, irrigation, ablution facilities, etc. and the Skorpion housing activities such as cleaning, ablution facilities, gardening, home and vehicle maintenance etc. that will release effluent to the sewer, or storm water systems are classified as domestic water.

Biodisc sewage treatment plants located at Skorpion Zinc and Rosh Pinah respectively treat raw sewage generated at both the site and village. The treated effluent will be discharged (as per the conditions of the permits issued by the MWARD) into existing dry streambeds if it cannot be recycled.

Although rivers in the area rarely flow, the stream channels and waterways must be kept free of contamination as they support important habitats for desert fauna and flora. Flash floods occur periodically and it is possible that more than 20mm may fall in a single rainstorm event and for local run-off to be very high.

11.6.2 Legal requirements

The Water Act (54 of 1956) governs the use and disposal of water. MWARD issue permits for effluent disposal for the refinery and the sewage treatment plants. See Appendix C and the legal register that will reflect any changes to legislation.
11.6.3 Goals and objectives

Minimise potential pollution of surface and ground water systems by domestic effluents from the mine and refinery, the Skorpion Zinc facilities at Lüderitz Harbour and the Skorpion village. Monitor the discharge of these effluents.

Skorpion Zinc will endeavour to reduce its water consumption, provided that the production of zinc, employee and family quality of life are not adversely affected. (See also section 12.11).

11.6.4 Management commitments for emissions to water (domestic)

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify significant potential sources of surface and ground water pollution at Skorpion Zinc, Lüderitz warehouse and the Skorpion Zinc village and identify the risks associated with these sources.</td>
<td></td>
</tr>
<tr>
<td>Any activities that pose a significant risk will be examined to determine possible practical and cost effective measures that can be put in place to manage this risk.</td>
<td></td>
</tr>
<tr>
<td>Develop action plans as part of the EMS, to reduce or minimise these risks.</td>
<td></td>
</tr>
<tr>
<td>Review them annually.</td>
<td></td>
</tr>
<tr>
<td>Manage clean (storm water) and dirty (sewage) water systems separately and by preventing the disposal of hazardous waste into storm water and the sewage systems.</td>
<td></td>
</tr>
<tr>
<td>Monitor and maintain the sewage treatment plants and monitor the final effluents to ensure that they meet MWARD permitted standards.</td>
<td></td>
</tr>
<tr>
<td>The impact that the mine will have on the fossil aquifer underlying the pit will be determined when the pit approaches the level of the known water table.</td>
<td></td>
</tr>
<tr>
<td>Develop a management plan to deal with pit water and ground water quality.</td>
<td></td>
</tr>
<tr>
<td>Look for, and implement water saving measure where practical, and where the quality of life of employees and residents is not affected, at the mine or refinery and in the village.</td>
<td></td>
</tr>
</tbody>
</table>

11.6.5 Performance indicators and documentation for measuring compliance to commitments

- All SHE incidents will be recorded and reported upon and these records may be checked.
- The internal and external EMS audit results and reports can be reviewed.
- Soil and water pollution monitoring results can be checked, although groundwater monitoring is not expected to be undertaken until later during the life of mine.
- The EMS action plans and minutes of the various EMS review meetings can be reviewed to determine what action has been taken for activities identified as significant risks.
- Visual inspections to check the flow of clean and dirty water systems can be undertaken.
• The effluent disposal permit issued by the MWARD can be checked and the effluent monitoring test results compared against this.

• Inspection reports of the MWARD can be reviewed.

11.7 Aspect - Emissions to Water (Industrial)

11.7.1 Background

The refinery design incorporates a zinc extraction process that recycles and reuses water to such an extent that there should be almost zero effluent discharge from the refinery. In addition, a “dry” filter residue cake (tailings) will be produced that can be carried by conveyor to the tailings impoundment.

Industrial effluent is defined as all untreated process water from the refinery and mine. It has the potential to impact negatively on both surface and ground water resources because of the contaminants (heavy metals, oils etc) that may be contained within it. The ground water at Skorpion Zinc is located at about 187m below the surface and streambeds are usually dry, which makes the risk of water pollution very low.

However, in the event of a spill, contamination of the soil is likely as well as potential impacts on the desert eco-system. As the volume of industrial water produced during operations is very large, all reasonable measures need to be taken to prevent untreated effluents from pooling on surface casing soil contamination or damage to fauna or flora. To this end, a comprehensive and state-of-the-art evaporation pond system has been constructed for pollution control.

For the refinery conversion, the ABA results indicated that 1 part limestone should be used to neutralise 3 parts calcine leach residue. This yielded a paste pH of almost 6 and a leachate pH of 6.82. This is adequate to neutralise the calcine leach residue;

In order to reduce the metal concentrations in seepage from the calcine leach residue a pH of at least 7.6 should be obtained. To increase the pH from 6.8 to 7.6 would require a 50% increase in limestone. That means that 1 part limestone should be used to neutralize 2 parts calcine leach residue in order to reduce metal concentrations in seepage from residue material. As a further improvement, the blend ratio of 1:1 would minimize any potential contamination impact and is therefore recommended for safe co-disposal.

All effluent in the refinery is channelled to the effluent treatment plant where it is neutralised and solids are separated from the water. The treated water is then recycled back into the plant. Excess treated water drains into the evaporation ponds where it will evaporate or be used by the mining department for dust suppression on their haul roads and stockpiles. Contaminated water from the workshops at the mining complex pass through an oil separating system before the treated water is evaporated or used for dust suppression on the mine’s haul roads.
The tailings dump is not expected to produce any leachate, as the residue filter cake is an essentially dry product.

Sulphur will be temporarily stored at the warehouse at Lüderitz Harbour. Any wash down water containing sulphur residue will be contained in such a way that it does not discharge directly into the harbour.

11.7.2 Legal requirements

The Water Act (54 of 1956) governs the use and disposal of water. MWARD issue permits for effluent disposal for the refinery and the sewage treatment plants. See Appendix C and the legal register that will reflect any changes to legislation.

11.7.3 Goals and objectives

Protect, as far as is possible, water resources (ephemeral stream channels, deep aquifers and the harbour at Lüderitz) from becoming polluted, as a result of Skorpion Zinc’s activities by preventing the discharge of polluted industrial water into the environment.

11.7.4 Management commitments for emissions to water (industrial)

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify potential sources of industrial water pollution associated with Skorpion zinc’s operations and determine the risk associated with these sources/activities.</td>
<td></td>
</tr>
<tr>
<td>Develop action plans as part of the EMS to manage significant risks and to ensure rapid response should an incident arise.</td>
<td></td>
</tr>
<tr>
<td>This exercise will be repeated one year after commencement of operations.</td>
<td></td>
</tr>
<tr>
<td>Thereafter the EMS action plans will be reviewed annually.</td>
<td></td>
</tr>
<tr>
<td>Manage and maintain the evaporation ponds, oil/water separator system and sewage plants to ensure that they are operated to the highest standard and that all effluent is treated to an acceptable level before being discharged into the environment.</td>
<td></td>
</tr>
<tr>
<td>Monitor for possible seepage below the tailings impoundment and evaporation ponds.</td>
<td></td>
</tr>
<tr>
<td>Monitor effluent quality from the refinery treatment plant and mine oil separation system.</td>
<td></td>
</tr>
</tbody>
</table>

11.7.5 Performance indicators and documentation for measuring compliance to commitments

- All SHE incidents will be recorded and reported upon and these records may be checked.
- All the effluent monitoring reports may be checked against the permits issued by the MWARD.
- The EMS aspects registers and action plans pertaining industrial water all operational areas.
- The internal and external EMS audit results and reports can be reviewed.
- Borehole (if any) and soil monitoring reports may be accessed and the results compared.

11.8 Aspect - Local Noise

11.8.1 Background
Although Skorpion Zinc is situated in a remote part of the country and has no nearby receptors, the surrounding Sperrgebiet has been identified as a future conservation area with a particular focus on wilderness. Thus noise generated by the mine and refinery may impact negatively on the ambient noise levels. Once mining operations has seized at mine closure, the impact will be reduced.

11.8.2 Legal requirements
No Namibian law currently exists for noise, but the South African and World Bank Standards were consulted and personnel must use hearing protection when exposed to noise levels above 85 dBA. See Appendix C and the legal register that will reflect any changes to legislation.

11.8.3 Goals and objectives
Eliminate or reduce all unnecessary sources of noise.

Ensure that personnel are adequately protected against the effects of local (occupational) noise.

11.8.4 Management commitments for local noise

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the sources of greatest noise and, where necessary, periodically examine ways in which the noise can practically and cost effectively be reduced. Where applicable, action plans will be developed for significant noise sources and will be reviewed annually as part of the EMS.</td>
<td></td>
</tr>
<tr>
<td>As a minimum, provide personnel with personnel protective equipment when working near machinery that has an output in excess of 85dBA at 1m.</td>
<td></td>
</tr>
</tbody>
</table>

11.8.5 Performance indicators and documentation for measuring compliance to commitments
- The EMS aspects registers and action plans pertaining to noise in each operational area will be available for review.
- The occupational health monitoring results may be checked.
- Any test results measuring noise levels may be examined.
- The internal and external EMS audit results and reports can be reviewed.
- Operators working near noisy equipment should be wearing the appropriate protective equipment.
11.9 Aspect - Remote Noise

11.9.1 Background

The Land Use Plan complied for the Sperrgebiet has recommended that sections of the area remain as wilderness or be opened for limited recreational activity if the area is to be proclaimed a National Park. The wilderness experience implies that one will hear no sounds but those of the desert. Unfortunately sounds may be heard over considerable distances in the Namib because there are no other anthropogenic sources of noise. In addition, there is a relative absence of any vegetation. The only absorbers of sound generated by Skorpion Zinc will be the soft sands and topography surrounding the site. The noise generated from Rosh Pinah Zinc Corporation can be heard some distance into the Obib Mountains west of the village. Skorpion recognises, in its environmental policy, the fragile and unique environment in which it operates and the need to be compatible with other land uses. Any effort on the part of Skorpion to reduce noise at source will also reduce remote noise and once mining operations ceases at mine closure the impact will significantly be reduced.

11.9.2 Legal requirements

No Namibian law currently exists for noise, but the South African and World Bank Standards were consulted. See Appendix C and the legal register that will reflect any changes to legislation.

11.9.3 Goals and objectives

Reduce as far as possible the overall noise levels of the mine and refinery so that neighbouring farmers are not disturbed and visitors to the Sperrgebiet wilderness are not overly disturbed by remote noise from Skorpion.

11.9.4 Management commitments for remote noise

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the point sources of greatest noise and examine ways in which the noise can practically and cost effectively be reduced. Where applicable, action plans will be developed as part of the EMS and will be periodically reviewed.</td>
<td></td>
</tr>
</tbody>
</table>

11.9.5 Performance indicators and documentation for measuring compliance to commitments

- The I&AP register can be audited to see what complaints / compliments have been made by the public or employees.
- The EMS aspects registers and action plans pertaining to noise in each area on the mine and refinery will be available for review.
- The occupational health monitoring results may be checked.
11.10 Aspect - Consumption of natural resources - Energy Use

11.10.1 Background
Consumption of energy will contribute to the non-sustainable utilisation of fossil fuels globally. In addition, the use of any energy source, be it electricity, fossil fuels, wood, charcoal etc. contributes to elevated levels of atmospheric pollution, greenhouse gases and global warming. Namibia is a signatory to the UNFCCC (Climate Change) and it is known that Namibia is considered to be a net sink of carbon dioxide with carbon removals exceeding carbon emissions. Namibia’s greatest carbon dioxide (CO2) contribution to the atmosphere comes from the use of fossil fuels, such as diesel and petrol. Fossil fuels are non-renewable sources of energy.

The refinery at the Skorpion Zinc will utilise significant quantities of power in both the electrowinning and zinc melting activities and, as a result, Skorpion Zinc will use the equivalent of 25% of Namibia’s total electricity consumption. In addition, some ten thousand litres of diesel will be consumed per day to operate the mining vehicles and significant volumes will also be used for transportation of raw materials and SHG zinc to and from Lüderitz and in the operation of the light vehicle fleet. Although Skorpion Zinc has utilised the most efficient technology currently available in the design of the refinery, it is obvious that any further reduction in the consumption of power will reduce Skorpion’s contribution to atmospheric emissions as well as reduce operating costs.

During the refinery conversion phases, a 15% increase in power demand is expected when the two processes (i.e. processing of Zn Oxide and Zn Sulphide) run parallel during the period 2017 - 2021 (i.e. Refinery Conversion Phase 1). After this the power demand will decrease to pre 2017 levels when only Zn Sulphide will be processed and 5 550KWh/t Zn will be required.

11.10.2 Legal requirements
No Namibian or World Bank legislation exists for the use of energy. NamPower operates the local sub-stations under the Electricity Act 2 of 2000 and Regulations of 2001. See Appendix C and the legal register that will reflect any changes to legislation.

11.10.3 Goals and objectives
Monitor and manage energy consumption at the mine, refinery and village to ensure efficient use of energy.

Reduce, where possible, the consumption of all energy resources.
11.10.4 Management commitments for energy use

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine the various activities that use different energy sources.</td>
<td></td>
</tr>
<tr>
<td>Determine if there are cost effective and practical ways in which to improve the</td>
<td></td>
</tr>
<tr>
<td>energy efficiency, or the reduction in consumption thereof.</td>
<td></td>
</tr>
<tr>
<td>Where applicable, develop action plans as part of the EMS and review them annually.</td>
<td></td>
</tr>
</tbody>
</table>

11.10.5 Performance indicators and documentation for measuring compliance to commitments

- Energy usage reports should be reviewed together with the consumption figures produced by NamPower.
- The EMS aspects registers, action plans and minutes of department meetings pertaining to energy use in each area on the mine and refinery will be available for review.
- The internal and external EMS audit results and reports can be reviewed.
- Visual inspection of energy saving measures in the offices can be made.

11.11 Aspect - Use of Natural Resources (Water, Ore, Land etc)

11.11.1 Background

The past few decades have seen the emergence of a new paradigm concerning the use of the world’s natural resources, which has influenced to some extent the way in which industry operates. Industrial thinking is moving towards a new mindset in which the environment, that provides the natural capital (water, oxygen, soil etc), which is integral to a functioning economy, is recognised, given appropriate value and managed in a more sustainable manner. This new paradigm, “Natural Capitalism”, recognises the critical interdependency between the production and use of human-made capital and the maintenance of natural capital (air, water, eco-system services etc.). Man is beginning to understand the real value of natural systems and their ability to regenerate certain essential resources (e.g. oxygen), and needs to include this value when evaluating the cost of negative impacts on the environment. Industry is thus beginning to change its thinking about the way in which products are designed, produced and used and emerging trends are focussing attention towards more efficient or reduced resource use, reduction in waste and pollution prevention. Skorpion Zinc will adopt a similar approach for better environmental performance.
The oxidised zinc ore body at the Skorpion Zinc mine is a non-renewable natural resource and the mine and refinery therefore has a responsibility to extract and process the ore in as efficient manner as is possible so that no resources are wasted. Apart from the zinc ore, other resources such as aggregate, sand and limestone for the refining process will be quarried from time to time, depending on need.

11.11.2 Legal requirements

There are currently no Namibian or World Bank requirements applicable to land use or to soils. The Water Act of 1956 governs the use of water and the Minerals Act of 1992 governs the use of precious, rare and base minerals and industrial minerals. See Appendix C and the legal register will reflect any changes to legislation.

11.11.3 Goals and objectives

Strive for efficient utilisation and / or consumption of the natural resources used by Skorpion Zinc. This includes, ore, water, limestone, seed bank etc.

Limit the extent of the footprint of the mine and refinery as much as is possible.

Rehabilitate available disturbed areas to as close to the wilderness state as is practical, on an ongoing basis, and before closure.

11.11.4 Management commitments for use of natural resources

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify activities at Skorpion Zinc and the village that use water and determine if there are cost effective and practical ways in which to reduce the use or wastage thereof, provided that zinc production, employee health, or quality of life is not adversely affected. Where applicable develop action plans as part of the EMS and review them annually.</td>
<td></td>
</tr>
<tr>
<td>In order to reduce negative impacts on flora and fauna, the area of land surface disturbed by Skorpion Zinc’s activities will be kept to a minimum through integrated planning and track management. Disturbed areas will be sufficiently rehabilitated to encourage the growth requirements of the indigenous flora so that the land may again be used as a wilderness area.</td>
<td></td>
</tr>
<tr>
<td>Initiate a topsoil / see bank management programme if they are found to be a viable resource for rehabilitation.</td>
<td></td>
</tr>
<tr>
<td>Ensure that a mini environmental assessment is undertaken and an EMP is produced if new quarry sites are identified for the extraction of sand, aggregate etc. This will be done prior to commencement of that activity. In addition, ensure that rehabilitation of the borrow pits or quarries is undertaken on closure.</td>
<td></td>
</tr>
<tr>
<td>Endeavour to mine the ore body as efficiently as possible so as to minimise potential loss of any contained mineral resources. Stockpile marginal ore in the event that future technology/economics will allow cost effective processing thereof.</td>
<td></td>
</tr>
</tbody>
</table>
Endeavour to remove from the ore, as efficiently as possible, all the valuable contained minerals so that resource is not lost to the tailings impoundment.

<table>
<thead>
<tr>
<th>Process technology will be routinely reviewed to endeavour to efficiently and effectively extract the minerals and to reduce the use of other raw materials (water, sulphur prills etc) consumed in the process.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ore that contains potentially recoverable quantities of minerals other than zinc will be stockpiled against future use. Other minerals extracted as by-products from the refinery process will be stored in an environmentally acceptable manner until sufficient quantities are available to be sold.</td>
</tr>
</tbody>
</table>

11.11.5 Performance indicators and documentation for measuring compliance to commitments

- The results of the revegetation and rehabilitation plans may be reviewed.
- Visual inspection of disturbed and rehabilitated areas may be undertaken.
- The Life of Mine Plan and Closure plans will detail how Skorpion Zinc will rehabilitate and prepare for closure of the mine towards the end of the life of the mine.
- Refinery and laboratory production figures will show whether the mine and refinery are operating efficiently.
- Raw material usage figures (water, etc) will be available for review.
- The water balance for Skorpion Zinc can be examined.
- The EMS aspects registers, action plans and minutes of the various EMS review meetings can be reviewed.
- The internal and external EMS audit results and reports can be reviewed.
- Borehole (if any) and soil monitoring reports will be available for review.

11.12 Aspect - Use of Manufactured Materials

11.12.1 Background

Natural resources are required to manufacture materials and the more mankind consumes, the more strain is placed on our natural resource base. Many manufactured materials do not decompose readily and therefore become a waste issue. Efficient use and consumption of manufactured materials is therefore important. Substitution of manufactured materials that are more environmentally friendly is desirable.

Examples of manufactured materials includes paper, reagents, electronic equipment, furniture, stationary, paints, lubricants, material, vehicles etc.

11.12.2 Legal requirements

The is no legislation pertaining specifically to the use of manufactured materials except for those that refer to the transport, storage, use and disposal of hazardous materials such as the Hazardous Substances Ordinance No 14 of 1974. See the waste section of Appendix C and the legal register that will reflect any changes to legislation.
11.12.3 Goals and objectives

Minimise the use of manufactured materials, and/or substitute those manufactured materials that have adverse environmental effects (during their production, use or disposal) for more environmentally friendly products in order to reduce Skorpion Zinc’s greater environmental impact. The use of more resource efficient or more readily biodegradable products is desired, provided that the efficiency or effectiveness of the mining and refining processes are not compromised. Consider the life cycle analysis of the different product alternatives when deciding on the most suitable product.

11.12.4 Management commitments for the use of manufactured materials

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce an inventory of the manufactured goods used at Skorpion Zinc and determine the environmental risks associated with the use thereof. Determine if there are alternative products available, or more efficient ways to utilise the existing product, or reduce the use of environmentally “unfriendly” products. Review this list periodically.</td>
<td></td>
</tr>
<tr>
<td>Process the ore as cost effectively as possible to maximise the efficient use of manufactured materials in the process. Continuously review process technology to endeavour to efficiently and effectively extract the minerals while reducing the use of manufactured materials consumed in the process (acid, reagents etc).</td>
<td></td>
</tr>
</tbody>
</table>

11.12.5 Performance indicators and documentation for measuring compliance to commitments

- Skorpion’s purchasing protocols will reflect an effort to find and substitute more environmentally friendly and effective manufactured materials.
- Refinery and laboratory production figures will show usage / consumption trends of manufactured materials.
- The reports of special projects commissioned periodically to review process technology may be reviewed (Skorpion Zinc, however, retains the right to protect its process technology).
- The manufactured materials inventory will list products used on site.
- Cleaning products and pesticides used on site can be checked visually.
- Every area where chemicals or hazardous materials are stored and used will have Materials Safety Data Sheets available for referral.
- EMS aspects registers, action plans and minutes of the various EMS review meetings can be reviewed.
- The internal and external EMS audit results and reports can be reviewed.
11.13 Aspect -Visual Impact

11.13.1 Background

The Karas region, in which Skorpion Zinc is situated, is the poorest, most sparsely populated region in Namibia. Currently mining is its main economic activity. With likely proclamation of the Sperrgebiet as a national park, and the forthcoming signing of a Transfrontier Conservation Park that includes the Huns-Ai-Ais Nature Reserve and the South African Richtersveld National Park, it is probable that tourism will play a greater role in the economy of the Karas region.

Skorpion Zinc’s mine lease and accessory work area has been fenced out of the Sperrgebiet, primarily to avoid security issues associated with control of the restricted area, but is otherwise contiguous with the landscape of the Sperrgebiet and surrounding farms. To ensure that this particularly scenic landscape is not compromised from a visual perspective (in the short and long term), Skorpion Zinc has already incorporated some sensitive features into its design but still needs to minimise the visual impacts created by their activities during operation and at closure.

Skorpion Zinc’s activities also extend to Rosh Pinah, where the employees reside. It is envisaged that the areas surrounding the settlement of Rosh Pinah will, in time, become part of a greater conservation area. Skorpion’s development activities in the village should therefore be managed in an attempt to reduce negative visual aspects on the surrounding area.

11.13.2 Legal requirements

There are no legal or World Bank requirements applicable with respect to visual aspects. However, landscapes are defined as part of the human environment in pending environmental legislation. See Appendix C and the legal register that will reflect any changes to legislation.

11.13.3 Goals and objectives

Reduce and mitigate wherever possible the negative visual aspects of Skorpion Zinc’s activities in the southern Karas region, during operations and at closure.

11.13.4 Management commitments for visual impact

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify those facilities/activities that give rise to a negative visual impact,</td>
<td></td>
</tr>
<tr>
<td>determine the significance associated with that facility/activity and where applicable</td>
<td></td>
</tr>
<tr>
<td>develop action plans to address these impacts where practical and feasible.</td>
<td></td>
</tr>
<tr>
<td>Review these action plans regularly.</td>
<td></td>
</tr>
</tbody>
</table>
The long-term visual impacts of structures such as the tailings impoundment and waste rock dumps will be investigated to determine if it can be partly mitigated. Rehabilitation of these structures will only be to a point where natural rehabilitation processes can again take place.

Minimise, where possible and safe to do so, any light pollution, skyward and towards the Sperrgebiet.

Reduce dust emissions from disturbed surfaces as soon as is possible through the implementation of dust control methods and through rehabilitation of disturbed areas.

11.13.5 **Performance indicators and documentation for measuring compliance to commitments**

- Skorpion’s commitment to lessening visual impacts, where practical, can be inspected visually.
- The rehabilitation, Life of Mine and Closure plans will have commitments to visual rehabilitation.
- EMS aspects registers, action plans and minutes of the various EMS review meetings can be reviewed.
- The internal and external EMS audit results and reports can be reviewed.

11.14 **Aspect - Vibration**

11.14.1 **Background**
Vibration caused by blasting, ball mills, compaction and road maintenance can cause structural damage to buildings and equipment if consistent or extremely drastic. This could lead to the failure of a structure that could result in spills of hazardous materials, apart from negatively affecting production. In addition, vibrations can add to the overall noise levels of the site or area where it occurs.

11.14.2 **Legal requirements**
There is no Namibian or World Bank legislation pertaining to vibration. See Appendix C and the legal register.

11.14.3 **Goals and objectives**
Reduce unnecessary vibrations where practical and cost effective.

11.14.4 **Management commitments for vibration**

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify those facilities/activities that give rise to vibrations, determine the significance associated with that facility/activity and where applicable develop action plans as part of the EMS. Review these plans annually.</td>
<td></td>
</tr>
</tbody>
</table>
11.14.5 **Performance indicators and documentation for measuring compliance to commitments**

- Excessive vibrations can be observed during site inspections.
- EMS aspects registers, action plans and minutes of the various EMS review meetings can be reviewed.
- The internal and external EMS audit results and reports can be reviewed.

11.15 **Aspect - Smell / Odour**

11.15.1 **Background**

The air quality at Skorpion Zinc and in Rosh Pinah is good and there are virtually no industrial or domestic sources of unpleasant odours. However, the refinery and acid plant at Skorpion Zinc will produce several gases, some of which may be malodorous - sulphur dioxide has a noxious smell that can be likened to that of rotting eggs. Poorly managed waste sites, particularly those containing large quantities of putrefiable waste or that burn rubbish, and sewage plant / septic tanks are also sources of unpleasant odour and can contribute to unpleasant working or living conditions.

11.15.2 **Legal requirements**

References pertaining to odour are to be found in Section 101 of the labour Act 6 of 1992, the Atmospheric Pollution Prevention Act 45 of 1965, the Atmospheric Pollution Prevention Ordinance 11 of 1976. See Appendix C and the legal register that will reflect any changes to legislation.

11.15.3 **Goals and objectives**

Manage olfactory pollution of the atmosphere in the vicinity of Skorpion Zinc and where possible, reduce odours in the village and associated with the guesthouse, shift workers village, sewage plants and with recreational activities.

11.15.4 **Management commitments**

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify those facilities/activities that give rise to unpleasant odours, determine the significance associated with that facility/activity and where applicable develop action plans as part of the EMS. Review these plans annually.</td>
<td>C/A/I</td>
</tr>
<tr>
<td>Monitor SO$_2$ emissions and ensure that SO$_x$ emissions are maintained below the World Bank Guidelines thresholds during normal operations and that the duration and frequency of abnormal releases are minimised.</td>
<td>C/A/I</td>
</tr>
</tbody>
</table>
11.15.5 Performance indicators and documentation for measuring compliance to commitments

- The I&AP register can be audited to see what complaints / compliments have been made by the public or employees.
- EMS aspects registers, action plans and minutes of the various EMS review meetings.
- The internal and external EMS audit results and reports can be reviewed.
- A site inspection will determine if there are malodorous gasses being emitted.
- All SHE incidents will be recorded and reported upon and these records may be checked.

11.16 Aspect - Impact on Biodiversity

11.16.1 Background

Biodiversity is the measure of the variety of different species that are found in a given area and does not necessarily relate to density or abundance.

Skorpion Zinc is situated in the Succulent Karoo biome, which has been recognised as a global biodiversity hotspot. This biome is the only arid biome that exhibits such a high variety of flora and fauna, of which about 40% is endemic. Much of the biome in southern Africa has already been lost as a result of overgrazing. It is therefore essential to minimise further loss of this biome and to actively conserve it wherever possible. Namibia is a signatory of the Convention on Biological Diversity and as such, has a commitment to the preservation of rare and endemic species within its territory. The Succulent Karoo has been identified as one of the areas in need of conservation in the national biodiversity programme.

The extreme aridity and high winds in the area make it difficult for plants to establish themselves. Once established, their tenuous existence will be threatened by any disturbance to the environment such as destruction of habitat, changes in soil structure, exposure to increased dust levels and possible air-borne pollution. Numerous animal species are dependent upon the highly adapted and specialised vegetation that is found on the in the Skorpion Zinc area. It is therefore important to protect the vegetation as this will, in turn, protect the animals and insects found there.

As the greatest diversity and density of plants are found on the koppies and mountains, emphasis should be placed on conserving these habitats. Notwithstanding, some of the endemics are found exclusively on the sandy plains and their importance should not be forgotten.
11.16.2 Legal requirements
Namibia is a signatory to the Convention on Biological Diversity and Skorpion Zinc used World Bank Standards during the environmental assessment. A permit to remove plants is required under the Nature Conservation Ordinance No 74 of 1975. See Appendix C, and the legal register that will reflect any changes to legislation.

11.16.3 Goals and objectives
Avoid, or reduce, the potential negative impacts on the biophysical environment and subsequent loss of habitat and biodiversity.

Where applicable, undertake studies on vegetation, soils and desert ecology to develop an understanding of the consequences of aspects such as emissions on the ecosystems, and to improve rehabilitation efforts.

Ensure that there is no unauthorised movement of livestock, game or plants across the Sperrgebiet / Skorpion boundary fence.

Consider alternatives to compensate for biodiversity that has been lost as a result of the mining operation. Identify projects that will ameliorate/substitute/improve the loss of biodiversity in the area as a result of Skorpion Zinc's activities.

11.16.4 Management commitments to biodiversity protection

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify those facilities/activities that impact detrimentally on natural ecosystems, determine the significance associated with that facility/activity and where applicable develop action plans as part of the EMS. Review these plans annually.</td>
<td></td>
</tr>
<tr>
<td>Conduct an environmental assessment and update this EMP when major changes are made to process technology, there are additions to the infrastructure, or areas outside the scope of this EMP are to be disturbed.</td>
<td></td>
</tr>
<tr>
<td>Implement a vegetation monitoring programme to determine the effects, if any, that may occur on the surrounding vegetation as a result of Skorpion Zinc’s activities. Review the programme annually.</td>
<td></td>
</tr>
<tr>
<td>Provide environmental awareness to employees and their families to develop an awareness and understanding of the natural environment.</td>
<td></td>
</tr>
<tr>
<td>Limit physical disturbance or loss of important habitat for fauna and flora, particularly on rocky outcrops, inselbergs and gravel plains as far as is practicably possible.</td>
<td></td>
</tr>
<tr>
<td>Where possible, rescue rare and endemic plants from areas earmarked for disturbance. Use these plants for rehabilitation of disturbed sites Skorpion Zinc gardens, or for restoration experiments (cuttings, propagation etc).</td>
<td></td>
</tr>
</tbody>
</table>
Management Commitment

Yes or no? C/A/I

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop a policy regarding the flora that may be used for landscaping at Skorpion</td>
<td></td>
</tr>
<tr>
<td>Zinc and in the village.</td>
<td></td>
</tr>
<tr>
<td>Report to the authorities any person (be they employees, or family members,</td>
<td></td>
</tr>
<tr>
<td>contractors or suppliers) found to be involved in poaching or the illegal trading</td>
<td></td>
</tr>
<tr>
<td>of plant or animals.</td>
<td></td>
</tr>
<tr>
<td>Engage in dialogue with other existing and potential new industries or mines in the</td>
<td></td>
</tr>
<tr>
<td>area in order to reduce the cumulative negative effects of the impacts that the</td>
<td></td>
</tr>
<tr>
<td>combined activities could have on this area. (Strategic Environmental Assessments).</td>
<td></td>
</tr>
<tr>
<td>Participate in, or contribute to, or undertake research on, environmental issues</td>
<td></td>
</tr>
<tr>
<td>considered relevant to Skorpion Zinc or to the biodiversity and ecology of the area</td>
<td></td>
</tr>
<tr>
<td>in which the mine and refinery is situated.</td>
<td></td>
</tr>
</tbody>
</table>

11.16.5 Performance indicators and documentation for measuring compliance to commitments

- The I&AP register can be audited to see what complaints / compliments have been made by the public or employees.
- EMS aspects registers, action plans and minutes of the various EMS review meetings can be reviewed.
- The internal and external EMS audit results and reports can be reviewed.
- Observations made during a site visit will confirm if the various commitments made above are being implemented or not.
- All SHE incidents will be recorded and reported upon and these records may be checked.
- The rehabilitation program and results will be available for review.
- Induction, awareness and other training programmes registers may be reviewed.
- The SO2 and dust vegetation monitoring program results will be available for review.

11.17 Aspect - Other (e.g. Archaeology, heritage and historical sites)

11.17.1 Background

Several archaeological sites dating from Early Stone Age to late Stone Age have already been discovered in the Skorpion Zinc area and cave sites are known to exist on some of the inselbergs nearby. Any area that appears to be suitable as a potential campsite or resting-place today is most likely to have already been used for similar purposes by the earlier hunter gatherers of this area.
The known and important sites that may be impacted by Skorpion Zinc construction and mining activities have already been excavated.

11.17.2 Legal requirements
There is no existing law pertaining to palaeontology. However, archaeological sites are governed by the National Monuments Act of 1969. See Appendix C and the legal register for changes to legislation.

11.17.3 Goals and objectives
Avoid disturbance of known or unknown archaeological / palaeontological sites and ensure that mining activities do not destroy archaeological or historical sites without the necessary permission being granted by the National Monuments Council (NMC) or equivalent.

11.17.4 Management commitments for archaeology

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the event of future developments consult the site sensitivity map and avoid, where possible, known archaeological sites. Document new finds and report them to the NMC.</td>
<td></td>
</tr>
<tr>
<td>During stripping operations check sedimentary rocks, such as clays or silts that may be found as lenses or discrete bands within the overburden calcretes for potential fossils (other than fossil gastropod shells of the genera <em>Trigonephrus</em> and <em>Dorcasia</em>). Keep records of findings.</td>
<td></td>
</tr>
</tbody>
</table>

11.17.5 Performance indicators and documentation for measuring compliance to commitments

- Review archaeological reports pertaining to excavations and mapping of sites that were disturbed.
- The archaeological map produced in the EA can be used to physically inspect known sites of interest.
- Periodic geological reports will note if fossils other than the fossil land snails have been found in the pit overburden.

11.18 Aspect - Impact on socio-economic & safety and health issues
The definition of environment as used by Skorpion includes social and economic aspects. Skorpion therefore acknowledges that its employees are a resource that should be developed in order for individuals to improve their life and working skills.
Socio-economic issues that were identified in the EA included the anticipated in-migration of job seekers to Rosh Pinah - a mining village that has inadequate infrastructure to support them. Efforts were made to discourage workers from moving to Rosh Pinah in the hope of securing work, in order to minimise the pressures on the existing facilities and on the social fabric of the existing village. As it is, the development of Skorpion Zinc village has resulted in an increase in the size of Rosh Pinah to almost three times what it was before.

Concomitant with the influx of the workforce was the potential spread of sexually transmitted diseases, particularly the AIDS virus. The issues of health and AIDS awareness were addressed in induction programmes and other periodic events throughout construction.

RPZC and Skorpion Zinc have jointly, through RoshSkor (Pty) Ltd, had Rosh Pinah de-proclaimed from the Ai-Ais Huns Nature Reserve in which it was situated, and are in the process of getting the village proclaimed as a settlement. Thus in the long term, the town will be managed by a governmental local authority. In the short term, each mine will continue to manage their respective sections of the town and will have to provide basic services such as waste management, water, electricity, and social (e.g. security) and recreational needs for the resident communities. This is being done, in part by RoshSkor, which is made up of representatives from both mines.

Positive socio-economic impacts associated with Skorpion Zinc include increased revenue to the Namibian economy, and increased opportunities for industries supplying mine needs, and through employment. Some 570 personnel, most of whom will be Namibian, will be employed full time at Skorpion Zinc.

The closure of the mine in 2019 will negatively affect the local community and the Namibian economy as a whole. By extending the life of the existing processing plant through the proposed modifications to process ZnS Ore, the proposed conversion could have significant socio-economic benefits including increased employment opportunities, on-the-job training, increased spending power, and economic knock-on effects felt locally in Rosh Pinah. The proposed activities would extend the life of the processing plant and in so doing extend the period that positive impacts are felt.

Because the site is already established (i.e. existing infrastructure), the possible negative effects typically associated with the construction of a mine will be avoided or minimized and thus the status quo will remain:

- the existing infrastructure (including housing, services, sewerage system and road infrastructure) of Scorpion Zinc can be taken over by NamZinc,
- no change to the current visual impact is expected due to the modifications to the plant,
- the impacts associated with air emissions are expected to be less than what it currently is,
- there will be no change in land use and potential nuisance activities to surrounding neighbors will be the same or less,

The influx of unskilled job seekers into Rosh Pinah as soon as project construction/commencement is announced is a potential concern since it could add to the current unemployment rate and can further contribute to existing social ills.

Hazardous substances and wastes in water, air, and soil can have serious, negative impacts on public health. The term ‘hazardous substances’ is broad and includes all substances that can be harmful to people and/or the environment. Because of the quantity, concentration, or physical, chemical or infectious characteristics, hazardous substances may:

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

11.18.1 Legal requirements
The Minerals Act of 1992 and World Bank Operational directives were used to guide the socio-economic assessments. All legal requirements concerning Health and Safety will form part of the H&S Management Systems at Skorpion Zinc. See Appendix C and the legal register that reflect any changes to legislation.

11.18.2 Goals and objectives
Reduce the potential negative social impacts that the Skorpion Zinc mine and refinery may have on the local environment and to enhance the positive aspects where applicable.

11.18.3 Management commitments to socio-economic, safety and health issues

<table>
<thead>
<tr>
<th>Management Commitment</th>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify those facilities/activities at Skorpion zinc and in the village that impact detrimentally the social and economic well being of the town. Determine the significance associated with that facility/activity and where applicable develop action plans as part of the EMS. Review these plans annually.</td>
<td></td>
</tr>
<tr>
<td>Address all safety and health issues associated with the mine, refinery and village via the safety and health department. Integrate safety, health and environmental management systems.</td>
<td></td>
</tr>
<tr>
<td>Keep an open and constructive dialogue with the landowners of property immediately adjoining the site or other I&amp;APs who may be impacted upon by Skorpion's activities. These include, amongst others, the Ministry of Mines and Energy and Ministry of Environment and Tourism (for issues concerning the Sperrgebiet), Namdeb security, Lüderitz Harbour</td>
<td></td>
</tr>
</tbody>
</table>
Management Commitment

<table>
<thead>
<tr>
<th>Yes or no? C/A/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>authorities, and Ambase Exploration, Kumba Resources and other exclusive prospecting licence (EPL) holders in the area.</td>
</tr>
<tr>
<td>Communicate openly, through structured fora, with the local community of Rosh Pinah and with other communities from which it draws its labour, or on which it operation impact (e.g. Luderitz community).</td>
</tr>
<tr>
<td>Establish a formal system for the recording of, and response to, complaints / compliments about Skorpions activities.</td>
</tr>
</tbody>
</table>

11.18.4 Performance indicators and documentation for measuring compliance to commitments

- Safety and Health risk assessments can be reviewed.
- EMS aspects registers, action plans and minutes of the various EMS review meetings.
- The internal and external EMS audit results and reports can be reviewed.
- I&APs can be questioned about Skorpion Zinc’s dialogue with them.
- The I&AP register can be audited to see what complaints / compliments have been made by the public or employees.
- All SHE incidents will be recorded and reported upon and these records may be checked.

11.19 Emergency Response Procedures

Emergency response procedures will be drawn up for all areas that are identified as a significant risk from a health, safety and financial point of view. Skorpion Zinc will ensure that measures that focus on protection of the environment are also included in these response plans as per the MET requirement made in the EA review.

11.20 Rehabilitation, Decommissioning and Closure

Rehabilitation of areas disturbed created during construction and operations will, as far as possible, be undertaken on an ongoing basis, so that the costs thereof can be absorbed into working costs, rehabilitation techniques can be tested, and so that disturbed areas are not left to actual closure, when the availability of resources could be diminished.

A comprehensive rehabilitation program is being developed to ameliorate the areas disturbed by construction activities.
Revised life of mine plans and closure plans will be drawn up for Skorpion Zinc and will be communicated to the relevant Ministries once complete. Environmental commitments included in these documents will be undertaken at different times during the mine and refinery’s life cycle, and will be managed as part of the EMS. The financial provisions provided in the final feasibility study (2000) closure plan will remain valid (See section 6).

11.21 New Projects / Additions / Technology or Process Changes
Skorpion Zinc will conduct an environmental assessment and update this EMP when major changes are made to process technology, there are additions to the infrastructure, or areas outside the scope of this EMP are to be disturbed. The Skorpion EMS will have in place a procedure that will ensure that an environmental impact and risk assessment for any new products, projects or process changes that take place.

11.22 Cumulative Impacts Management
Skorpion Zinc is not the only mine in the area and the potential exists for other new mines to be developed. The socio-economic considerations of Skorpion Zinc and other mines nearby is an example of one of the cumulative impacts that should be managed by all involved in the area.

As part of their social and environmental responsibilities Skorpion Zinc will engage in dialogue with local authorities, Ministries, other existing and potential new industries or mines in the area, in order to identify, reduce or manage the negative cumulative impacts and to enhance or promote the positive impacts that the combined activities could have on this area.

12 COMPLIANCE AUDITING OF THE EMP

12.1 Bi-Annual Reporting
Skorpion Zinc will produce bi-annual reports to meet the requirements of the Environmental Contract requested as a condition of the Mining Licence for submission to the MET. The reports will cover the period January to July and August to December according to the guidelines supplied by the MET. The Bi-Annual reports will document current compliance with the existing legal requirements, and describe progress toward meeting the commitments outlined in this EMP.
12.2 MET Inspections

According to the Environmental Contract, officials from the Ministry of Mines and Energy and/or the MET may at any time conduct a compliance and/or performance inspection of Skorpion Zinc’s operations. Skorpion Zinc encourages such inspections but insists that they be arranged as formal visits. Skorpion Zinc should also be provided with a written report of the findings of the inspection. This is requested for all inspections/audits carried out at Skorpion Zinc, whether conducted by authorities, head office, NGO’s or accrediting bodies. Skorpion has committed itself to continual improvement and will use such feedback to help improve its overall operations.

12.3 EMS Audits - ISO 14001

The protocol and schedules for internal and external audits have been developed as part of the EMS and the relevant manuals are available upon request. At least one third party audit will be conducted annually, and internal second and first party audits will be conducted throughout the year.
APPENDIX A HAZARDOUS WASTE MANAGEMENT

1. HAZARDOUS WASTE MANAGEMENT STRATEGY

The hazardous waste streams at Skorpion Zinc can be classified into the following three major groups:

1. Tailings dam

All waste disposed at the tailings dam:
   a. Crud;
   b. ETP cake;
   c. Manganese dioxide; and
   d. Spent carbon.
   e. Filtered Sulphur

The Crud, Manganese dioxide, spent carbon and ETP Cake is classed as Hazardous Waste according to the waste classification systems. The Crud, Manganese oxide, spent carbon and ETP Cake makes up 1.4% of the material deposited on the tailings dam. This waste will be transported directly from the Skorpion Zinc Mine plant to the tailings dam.

Due to it being fed onto the conveyor with the tailings, no planned deposition strategy is undertaken.

2. Other hazardous waste:

   a. E-waste;
   b. Fluorescent tubes;
   c. Office waste (printer cartridges etc.)
   d. Laboratory waste;
   e. Hydrocarbons; and
   f. Other stored chemical waste.

 Handling:

- All hazardous chemicals will be handled and stored in accordance with their specific Material Safety Data Sheets (MSDS's).
- Where possible, diesel transferrals must take place in the designated refuelling areas on smooth, impervious surfaces.
- Drip trays will be positioned at each machine whilst being refilled. Drip trays will be drained into suitable containers. Smaller plant and tyre wheeled equipment will also re-fuel at the main storage areas.
Hazardous chemical substances will be used according to the manufacturer’s specifications. Care will be taken to avoid spills and unnecessary contact with any part of the environment for which they were not intended e.g. soil, water bodies and vegetation or animals.

Hazardous chemical substances shall be kept in clearly marked, closed containers and decanting will occur over a drip tray to prevent spillage, this will not take place within forty meters of any watercourse.

Disposal:
All other hazardous waste (fluorescent tubes, laboratory waste, E-waste, oil and greases, and chemicals) will be transported to the Walvis Bay H:h site. All required negotiations with the Walvis Bay H:h site have been completed and the necessary transport permits obtained from the relevant authority (refer to Part 4 of this Appendix). A Transport Risk Assessment has been compiled by Skorpion Zinc and is included in Part 3 of this Appendix.

3. Vanadium pentoxide.
The agreement reached between Skorpion Zinc and the Walvis Bay Municipality includes the disposal of Vanadium Pentoxide at the Walvis Bay H:h site.

2. HAZARDOUS WASTE MONITORING SCHEDULE AND PROCEDURES

1. Groundwater
The Skorpion tailings contain 38-42% moisture. Even given the climatic conditions (B-), the tailings will generate some leachate. The solubility and pH dependence of certain elements has not been investigated. It is also not known how the liquid organics from the Crud and carbon will behave in the tailings dam and whether it will stay in suspension or will migrate with the leachate into the groundwater environment. The liquid organic portion of the Crud is a light non-aqueous phase liquid (LANPL) and as a result will “float” on water.

The organic portion of the Crud is a hydrocarbon which naturally decays over time.

In order to determine the risks of the disposal of the hazardous material at the tailings dam, the potential pathways (air & water) into the environment are being investigated and monitored.

Groundwater analysis of borehole BHT1 indicates active contamination of the groundwater by sulphates, chlorides and nitrates and some organics. In order to comply with the waste
disposal legislation, the potential impact of the current hazardous waste disposal at the tailings dam on the environment needs to be quantified.

Three dedicated monitoring boreholes were drilled around the tailings dam to monitor the potential migration of contamination from the tailings dam into the groundwater environment.

- Monitor groundwater quality in boreholes on a **monthly** basis:
- Inorganics: pH, TDS, anions, cations and trace elements Al, Mn, Fe, Zn;
- Organics: Sample for LNAPLS (free product);
- Sample for dissolved organics in the groundwater;
- Analysis must include: Total Petroleum Hydrocarbons (TPH) & BTEX.

The results of the monitoring programme must be analysed after one year’s monitoring.

The impact on the environment will be determined and if the impact is unacceptable, mitigation measures will have to be implemented. The impact will be measured using acceptable criteria and internationally accepted intervention levels.

*The following GCS (Pty) Ltd groundwater monitoring procedure will be utilised:*
GCS PROCEDURE

Groundwater sampling for inorganic determinants, trace and heavy metals

1. Borehole Setup
   - Ensure the correct sampling site has been located
   - Fill in a field sheet to record weather conditions, date, time and sample number.
   - Remove the borehole cap or cover

2. Pre-purging
   - Measure static pre-pumped water level and record it on the field sheet.

3. Purging
   - Install the pump in the borehole according to pump type and installation depth required.
   - Purge the hole to 3 volumes or until the EC stabilizes in order to remove all stagnant water.
   - Whilst purging the borehole, complete the laboratory custody sheet and mark the sample bottles.

4. Field Measurements
   - When the EC stabilizes, or three borehole volumes have been removed, measure and record the following parameters on the field sheet:
     - Temperature, EC, pH

5. Sample Collection
   - Major and minor ions: Use plastic sample bottles provided by the laboratory. Fill sample bottles to a volume of 2 liters, on-site filtration is not required if the borehole is well purged. No acidification is required.
   - Trace and heavy metals: Filter the sample to a volume of 500ml in a plastic bottle provided by the laboratory. Add nitric acid to pH<2 (approximately 2ml of 10% analytical grade nitric acid).
   - Label all sample bottles clearly indicating if filtration has been done and acid used for preservation.
6. Wrap-up

- Place the samples in a cooler-box with ice or ice-packs in order to protect them from light and keep them as cool as possible.
- Ensure all the laboratory forms are completed.
- Submit the samples to the laboratory as soon as possible after sampling.


2. Surface water

If runoff occurs from the tailings dam, this will enter the groundwater environment. Monitoring of this potential contamination needs to be further investigated.

3. Air quality

Air quality monitoring must take place through the sampling of dust fallout from 13 dust buckets located in strategic positions around the site. The dust must be analysed for the presence of various metals and compared to human consumption guidelines. It is recommended that the dust fallout be quantified in terms of dispersion.

The assessment of the maximum dust fallout and inhalable exposure to particulates due to air blown dust must take place for:

- Total Suspended Particulates (TSP);
- Inhalable Particulates (PM10);
- Respirable Particulates (PM 2.5);

The results of all dust monitoring must be compared with the SANS 1929 daily and annual limits as well as the World health Organisation Guidelines.

4. Vegetation and Soils

Vegetation and soils must be continually monitored in order to ensure that they are not being impacted through the pathways outlined above. Vegetation will be monitored visually and soil sampled will be taken in strategic locations down-gradient of the tailings dam.
5. Data Management

Monitoring results are entered into an electronic database as soon as results are available, and at no less than one monthly interval, allowing:

- Data presentation in tabular format,
- Time-series graphs with comparison abilities,
- Statistical analysis (minimum, maximum, average, percentile values) in tabular format,
- Graphical presentation of statistics,
- Linear trend determination,
- Performance analysis in tabular format,
- Presentation of data, statistics and performance on diagrams and maps, and
- Comparison and compliance to South African Water Quality Guidelines and any other given objectives.
3. DOCUMENTED APPROVAL (FORMAL AGREEMENT) FROM THE WALVIS BAY MUNICIPALITY REGARDING THE DISPOSAL OF HAZARDOUS WASTE.
09 June 2016
The Environmental Manager
Municipality of Walvis Bay
Department of Water, Waste & Environment
Private Bag 5917
Walvis Bay

Attention: Mr. David Uushona

Dear Sir,

Disposal of Hazardous Substance: Refinery Conversion Project

This letter has reference to the letter dated 23 March 2015 from Namzinc to your good office, requesting for the disposal of hazardous substances at your hazardous landfill facility and the subsequent email consent/approval from Mr. Rian Archer on the 14th April to accept the said hazardous waste at your facility.

The waste substances discussed and to be disposed off include:

Nickel Cake (Ni-Co) – 100 tonnes per year
Calomet (Mg2C2O4) – 20 tonnes per year

The chemical composition for the Nickel Cake and Calomet are respectively listed below.

Chemical composition of the Ni-Co cake

<table>
<thead>
<tr>
<th>Element</th>
<th>Dry solid composition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>5.0 - 10</td>
</tr>
<tr>
<td>Cu</td>
<td>10.0 - 16.0</td>
</tr>
<tr>
<td>Cd</td>
<td>1.5 - 2.5</td>
</tr>
<tr>
<td>Co</td>
<td>4.0 - 7.0</td>
</tr>
<tr>
<td>Ni</td>
<td>1.0 - 3.0</td>
</tr>
</tbody>
</table>

Signed: 2015/7/7


(*) Indian
(**) South African

Company Secretary: Smart Grant Angula (Windhoek) 24 Otan Street, Kleine Windhuk, Windhoek, Namibia

A member of the Vedanta Resources plc Group
<table>
<thead>
<tr>
<th>Property</th>
<th>Calomel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular formula</td>
<td>Hg₂Cl₂</td>
</tr>
<tr>
<td>Molar mass</td>
<td>472.09 g/mol</td>
</tr>
<tr>
<td>Appearance</td>
<td>White solid</td>
</tr>
<tr>
<td>Density</td>
<td>7.150 g/cm³</td>
</tr>
<tr>
<td>Melting point</td>
<td>526 °C (977 °F; 799 K) (triple point)</td>
</tr>
<tr>
<td>Boiling point</td>
<td>383 °C (721 °F; 656 K) (sublimes)</td>
</tr>
<tr>
<td>Solubility in water</td>
<td>0.2 mg/100 mL</td>
</tr>
<tr>
<td>Solubility</td>
<td>Insoluble in ethanol, ether</td>
</tr>
</tbody>
</table>

We therefore wish to take this opportunity to thank you for the positive consideration of our request and look forward to working with you.

Yours Sincerely,

Herman Frils
Project Manager

Muiderberg, 13/17
081 123 5017

No waste containing radio activity
APPENDIX B CURRENT LEGISLATIVE REQUIREMENTS-A SYNOPISIS OF CURRENT LEGISLATION

1. AIR QUALITY (INCLUDING DUST AND SO2)

<table>
<thead>
<tr>
<th>Emission</th>
<th>1 hour</th>
<th>24 hour</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO\textsubscript{2} (\textmu g/m\textsuperscript{3})</td>
<td>350</td>
<td>125</td>
<td>50</td>
</tr>
<tr>
<td>NO\textsubscript{x} (\textmu g/m\textsuperscript{3})</td>
<td>400</td>
<td>150</td>
<td>No limit</td>
</tr>
<tr>
<td>Total Particulates (&lt;10(\mu m))</td>
<td>No limit</td>
<td>120</td>
<td>60-90</td>
</tr>
<tr>
<td>Inhalable particulates (\textmu g/m\textsuperscript{3})</td>
<td>-</td>
<td>260</td>
<td>75</td>
</tr>
</tbody>
</table>

It must be noted that ambient dust conditions in the vicinity of Skorpion Zinc on occasion already exceed the WB Guidelines, as the area is extremely dusty due to the prevailing climatic conditions.

Other legislation and protocols make reference to emissions in as far as they may impact upon human health and safety in the work place and on reducing Greenhouse gas emissions. Regulations and protocols in which reference is made to emissions include the following:

- Atmospheric Pollution Prevention Act 45 of 1965,
- Atmospheric Pollution Prevention Ordinance 11 of 1976,
- Montreal Protocol on substances that Deplete the Ozone Layer of 1987
- Vienna Convention for the Protection of the Ozone Layer of 1995,
- United Nations Framework Convention on Climate Change of 1992,
- Draft Pollution Control and Waste Management Bill of 1999,
- Draft Environmental Management Bill (X) of 1998,

2. EMISSIONS TO LAND

2.1 Non Hazardous Waste


General domestic waste is mentioned in Section 101 of the Labour act 6 of 1992, Public Health Act 36 of 1919, the Draft Environmental Management Bill (X) of 1998; the Water Act 54 of 1956, the Draft Pollution Control and Waste Management Bill of 1999;
Reference is made to the management, transport and disposal of non-hazardous wastes in several regulations including, the Draft Pollution Control and Waste Management Bill of 1999, Draft Environmental Management Bill (X) of 1998, the Draft Pollution Control and Waste Management Bill of 1999.

2.2 Hazardous Waste

The South African Hazardous Substances Ordinance No 14 of 1988 has regulations pertaining to the disposal of hazardous materials.

The Water Act of 1965 also has regulations pertaining to the disposal of wastes to land and water.

Materials Safety Data Sheets (MSDS) that are produced for certain chemical and pharmaceutical products will be kept for, and referred to, for all hazardous materials that are used on site.

Other references pertaining to the transport and disposal of hazardous wastes may be found in the following:

- Section 101 of the Labour act 6 of 1992
- Draft Environmental Management Bill (X) of 1998
- Namibia’s Environmental Assessment Policy for Sustainable Development and Environmental Conservation of 1994,
- The Draft Pollution Control and Waste Management Bill of 1999;
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal;
- Hazardous Substances Ordinance 14 of 1974;
- Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade;
- Minerals (Prospecting and Mining) Act 33 of 1992;
- Draft Minerals Policy for Namibia, 2001
3. **EMISSIONS TO WATER**

Effluent discharges to water or land are governed by the Water Act (54 of 1956), which details the use and disposal of water. Permits for effluent disposal are issued by the Ministry of Agriculture, Water and Rural Development (MWARD).

Other legislation includes:

- Marine Pollution (Control and Civil) Liability Act 6 of 1981.
- The National Water Policy White Paper of 2000;
- The Draft Pollution Control and Waste Management Bill of 1999;
- Namibian Ports Authority Act 2 of 1994

4. **NOISE**

In the absence of Namibian standards for noise regulation in the ambient (as opposed to working) environment, the Noise Control Regulations of the South African Environment Conservation Act 73 of 1989 as well as the SABS Code of Practice 0103-1997 were consulted.

There are three requirements stipulated in the World Bank Guidelines with respect to workplace noise for Health, Environment and Safety on open-pit mining. These are:

- The use of feasible administrative and engineering controls, including sound-insulated equipment and control rooms to reduce the average noise level in normal work areas;
- Plant equipment should be well maintained to minimize noise levels; and
- Personnel must use hearing protection when exposed to noise levels above 85 dBA.


5. **CONSUMPTION OF NATURAL RESOURCES (ENERGY, WATER, LAND, ORE)**

The following list of regulations, policies and protocols all make all make reference to the protection, management and sustainable use of Natural Resources.

- The Namibian Constitution,
- Namibia’s Environmental Assessment Policy for Sustainable Development and Environmental Conservation of 1994,
- Draft Environmental Management Bill,
Energy is governed by the Petroleum Products and Energy Act 13 of 1990 (as amended) and Electricity Act 2 of 2000. Additional pending regulation and Southern African protocols concerning energy are listed below.

- Draft Parks and Wildlife Management Bill of 2002,
- Southern African Development Community: Protocol on Energy


6. USE OF MANUFACTURED MATERIALS

The Hazardous Substances Ordinance No 14 of 1974 has regulations pertaining to the use of manufactured materials. Materials Safety Data Sheets (MSDS) that are produced for certain chemical and pharmaceutical products will be kept for, and referred to, for all hazardous materials that are used on site.

7. VISUAL

There are no existing Namibian or World Bank requirements applicable with respect to visual aspects although mention of important landscapes is made in the Policy for the Conservation of Biotic Diversity and Habitat Protection of 1994.

Landscape is included in the definition of environment, especially the human environment, in the following draft legislation:

- Draft Environmental Management Bill (X) of 1998
- Draft Parks and Wildlife Management Bill of 2002
- Draft Pollution Control and Waste Management Bill of 1999.

8. VIBRATION

The World Bank Operational Directive OD 4.01 requires the Environmental Assessment to assess whether the project may be affected by seismic activities. This was undertaken and recommendations were made concerning the building standards that should be adopted.
Vibration is mentioned in the Section 101 of the Labour Act 6 of 1992 in terms of safety and health issues.

9. **ODOUR**

References pertaining to odour are to be found in Section 101 of the Labour Act 6 of 1992, the Atmospheric Pollution Prevention Act 45 of 1965, the Atmospheric Pollution Prevention Ordinance 11 of 1976, and in the Draft Pollution Control and Waste Management Bill of 1999.

10. **PROTECTION OF BIO-DIVERSITY**

Namibia is a signatory to the Convention on Biological Diversity and as such, has a commitment to the preservation of rare and endemic species within its territory. The World Bank promotes the conservation of endangered plant and animal species, critical habitats and protected areas (Para 9b of OMS 2.36 and Operational Policies 4.04).

The Nature Conservation Ordinance No 74 of 1975 regulates the removal and transport of endemic plants.

11. **ARCHAEOLOGY, HERITAGE SITES, OF HISTORIC MONUMENTS**

Cultural and natural elements that Namibia as a whole inherits from the past are currently protected by the South African National Monuments Act No. 28 of 1969, which remains in force by virtue of Clause 140 of the Constitution of Namibia.

Section 91 of the Namibian Minerals Prospecting and Mining Act (No. 33 of 1992) requires that archaeological finds be reported.

The World Bank states that it is committed to protecting archaeological sites, historic monuments and historic settlements (Operational Directive 4.01).

Other existing and pending legislation in which reference is made to cultural or heritage sites includes:

- Draft National Heritage Bill of 1999
- Draft Environmental Management Bill (X) of 1998
- Draft Parks and Wildlife Management Bill of 2002
- Namibia’s Environmental Assessment Policy for Sustainable Development and Environmental Conservation of 1994,

12. **SOCIO-ECONOMIC ISSUES**
Socio economic issues have to be considered according to Namibia’s Environmental Assessment Policy for Sustainable Development and Environmental Conservation of 1994. In Operational Directive 4.01, the World Bank lists as one of its key issues, the impacts of induced development and other socio-cultural aspects on the receiving socio-economic environment.

Other legislation that makes reference to socio economic issues includes the following.

- Draft Environmental Management Bill (X) of 1998;
- Draft Parks and Wildlife Management Bill 2002,
- Draft Pollution Control and Waste Management Bill 1999,
- Draft Minerals Policy for Namibia 2001,
- United Nations Convention to Combat Desertification 1994,
- National Water Policy White Paper 2000,
- SADC Protocols on Energy and Mining

13. **EMERGENCY RESPONSE PROCEDURES**

These are implied by several Acts and or Policies where the proponent is responsible for limiting the potential damage to environment through spillages and accidents etc.

Part 8 of the Draft Pollution Control and Waste Management Bill provides for accident prevention policies and emergency response plans.
APPENDIX C DUST ENTRAINTMENT & SUPPRESSION TECHNIQUES

Prepared for Skorpion Zinc
Intertek Commodities: Environmental Testing Services

Factors that affect dust entrainment include:
- The amount of surface dust;
- The particle size distribution, with larger particles requiring higher wind speeds for entrainment;
- The density of the particles, with denser particles (e.g. iron dust) requiring higher wind speeds for entrainment;
- Wind speed, with higher rates of dust entrainment at higher wind speeds; and
- Moisture level, with higher moisture levels increasing the mass of particles and binding particles together, that requiring higher wind speeds for entrainment.

This document assesses options for limiting the entrainment of dust in an industrial setting. Strategies that limit the entrainment of surface dust include those that:
- Remove dust from surfaces
- Increase surface roughness
- Obstruct wind flow
- Wet the dust source
- Chemically coat the dust source

These are discussed below.

1) Removal of Dust from Surfaces

The most effective approach to dust mitigation is good housekeeping through regularly sweeping and/or vacuuming of dust from open areas. Logically, if there is no dust on these surfaces, there will be no wind entrainment. A good housekeeping program of regular cleaning is necessary, together with regular checks and prompt response outside of the schedule if dust is noticed on any surfaces. Daily procedures and checks need to be recorded and signed off by the site manager.

Advantages:
- Cost effective.
- No specialised equipment or technologies required (other than cleaning equipment).

Disadvantages:
- Can be laborious if the production of dust onsite is continuous and substantial.
- This is not a once off application or procedure – cleaning needs to be repeated regularly.
2) Increased Surface Roughness

As described above, the entrainment of dust increases with wind speed. Surface roughness is relevant in that it reduces surface wind speed (Figure 1) and thus decreases the entrainment of dust and causes rapid fallout of dust already entrained. This is particularly relevant for heavier dust particles, such as iron. Figure 1 shows the differences in surface roughness between urban, suburban and rural settings, and the effect on surface wind speed. Smaller scale differences in surface roughness can also have significant effects on surface wind speed. For example, surface roughness increases with increased surface irregularities such as soil clods and angled particles. In large open areas, tilling of the soil in a series of ridges and ditches can decrease wind erosion from these surfaces (Figure 2). In an industrial setting, surface roughness can be increased by vegetating as much of the open areas as possible (grass or ground covers are particularly effective) or through the use of gravel beds. Scattering gravel on open sources slows wind speed at the surface and acts as a surface ‘armour’. Armouring occurs when finer particles fall between gravel particles and are protected from the wind by these particles. The use of gravel blankets significantly reduces wind erosion from open areas as long as the particles are greater than 2 mm in diameter (Chepil et al., 1963). Anything finer than gravel (e.g. coarse sand), therefore is not effective.

![Figure 12-1: Wind speed profiles for surface roughness categories - urban, suburban and open country](http://www.mfe.govt.nz/publications/air/good-practice-guide-atmospheric-dispersion-modelling/4-getting-started)
Figure 12-2: Series of soil ridges and ditches to limit wind erosion by decreasing wind speed (http://www.fao.org/3/a-x5670e/x5670e06.htm).

Advantages:
- Cost effective.
- Vegetating of surfaces has aesthetic advantages.
- No specialised equipment or technologies required for vegetating surface or laying gravel.
- Once off planting or application of gravel bed and limited maintenance required.

Disadvantages:
- Initial capital layout for vegetating surfaces or application of gravel bed.
- Vegetated surfaces need watering during dry conditions.

3) Wind Barriers

Wind barriers (fences, screens, hedges or tree lines) have two purposes - they can act as windbreaks, placed upwind to decrease wind speed before reaching the dust source, or can act as dust suppression barriers placed downwind of the source (Figure 3). The latter causes a sudden decrease in wind speed, resulting in rapid dust fallout, particularly of heavier and larger particles.
Figure 12-3: Barriers as windbreaks and dust suppression walls
(http://www.steelwindbreak.com/1-steel-windbreak-mechanism.html)

For windbreaks, fences with 30% to 40% porosity are optimal (Cecala et al., 2012) since solid barriers results in turbulence downwind of the fence, which increases erosion of the dust source (Figure 4). These fences should be a minimum of 3 to 5 feet (1 to 1.5 m) in height to be effective (Woodruff et al., 1977). Earthen banks with heights of 2 feet (~0.6 m) are also effective (Woodruff et al., 1977) as are treelines or hedges (Cecala et al., 2012). For dust suppression barriers, solid board fences are most effective but due to downwind turbulence and noise concerns, screens with some porosity tend to be utilised. Higher barriers (e.g. eight feet/2.5 m and above) offer excellent protection in particularly dusty settings, or where there are elevated dust surfaces. Optimal placement for maximum trapping efficiency is approximately 10 to 20 barrier heights upwind of the area to be protected (Cecala et al., 2012). Barriers that are oriented perpendicular to the prevailing wind direction reduce saltation at the soil surface, and reduce the amount of collected airborne particles downwind of the fences by 90% (Grantz et al., 1998). Figure 5 below shows the use of a fence to limit dust on an adjacent roadway.
Figure 12-4: Use of solid walls versus controlled porosity fences (http://weathersolve.com/wp-content/uploads/2013/06/wind-pattern-wall-1-940x836.jpg)

Figure 12-5: Use of fence as wind barrier (Cecala et al., 2012, page 266)

Advantages:
- Vegetating of surfaces has aesthetic advantages.
- Once off planting or installation of fences/earthen banks.

Disadvantages:
- Initial capital layout for vegetating surfaces or construction of fences/earthen banks
- Vegetated surfaces need watering during dry conditions.
- Fences require periodic maintenance.

4) Surface Wetting

The wetting of dusty surfaces is the most commonly used method to prevent dust entrainment. Water binds particles together, thus increasing size and weight, and less dust will be entrained at a specific wind speed than if the surface was dry. Alternate wetting and drying of sediment results in crusting which is the formation of a mechanically stable compacted and cemented upper surface that is resistant to erosion. However, once any erodible material has scoured and the crust has worn through, then rapid entrainment can occur (Chepil, 1957).

Hesketh and Cross (1982) indicated that watering control efficiency was found to be 50% for an unpaved roadway. A water content of 60 to 80 g/m² is the critical value to prevent dust entrainment at wind velocities of 7 to 15 m/sec for both smooth and rough surfaces (Tsai et al., 2003). After 210, 130, and 110 minutes at average wind velocities of 0, 2, and 4 m/sec respectively, the dust sample must be replenished with water to avoid dust entrainment (Tsai et al., 2003).

Advantages:
- Cost effective.
- Less labour intensive than removal of dust (particularly with automated wetting systems).
- No specialised equipment or technologies required (unless wetting system is automated).

Disadvantages:
- Water use concerns (e.g. difficulties during water restrictions).
- Difficulties associated with uniformity of application.
- Run off management.

5) Application of Chemicals

Chemical surfactants can be used as coatings to form a crust on a dust source to limit wind erosion. The mechanism is similar to that of water crusting but the chemical enhances the cementation and stabilisation of the crust. Chemical options include mineral salts, resins, acrylics and adhesives. Application of surfactants can be combined with water to lower surface tension for better interaction between water and certain types of dust that resist water absorption. These coatings and additives are preferably nontoxic to plants and water permeable. Chemical dust suppression is not routinely applied to localised sources of dust in industrial settings. This is likely due to cost considerations when water is sufficiently effective.
for thin, localised dust sources. The chemical option is usually only applied to largescale
stockpiles, conveyor systems or open areas.

Advantages:
- Highly effective if appropriate chemical is applied.
- Water savings.

Disadvantages:
- Chemical agents tend to be expensive.
- Difficulties in ensuring uniformity of application.
- Some chemicals require specialised application technologies (mixers, sprayers etc).
- Regular reaplication is necessary (frequency depends on material used and
  meteorology at site).
- Potential for contamination of soil and this may prove toxic to local flora and fauna.
References


