# TETE IRON ORE PROJECT

## WASTE AND WASTEWATER ASSESSMENT REPORT

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**Moçambique** |

December, 2014
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# CES Report Revision and Tracking Schedule

|----------------|-------------------------------------------------------------------------------------------------|
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Declaration of independence

I KEVIN WHITTINGTON-JONES, PhD declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed project, in application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

SIGNATURE:
Project background

Capitol Resources Limitada (Capitol Resources), a wholly owned subsidiary of Baobab Resources Plc (Baobab) - a Mozambique-focused iron ore, base and precious metal explorer, is proposing to develop the Tete Iron Ore Project (the project) located north of the provincial capital of Tete, in the Chiúta and Moatize districts of Mozambique. The project extends over three licence areas – 1032L, 1033L and 1035L (Figure 2.1) – all of which are 100% owned by Capitol Resources. The first phase of mining activity will occur in the 1035L licence area, which shares boundaries with Vale and Rio Tinto’s coal projects. The project will initially focus on the Tenge-Ruoni Prospect, an area of mineralisation containing magnetite, titanium and vanadium within a cluster of prospects called the Massamba Group, for the production of pig iron.

The Massamba Group, located approximately 55 km north-northeast of Tete, is composed of a cluster of four prospects of which the Tenge-Ruoni prospect will be mined first and is the focus of the scoping and the environmental and social impact assessment (ESIA).

Coastal & Environmental Services (CES) was contracted to prepare a waste management assessment report for the proposed Tenge-Ruoni project.

Terms of reference

A Waste Management Assessment is required to meet the requirements of International Finance Corporation (IFC) Performance Standards (PS) 3. It will focus on the environmental impacts that may arise from the handling, storage and disposal of solid and liquid wastes from the mining and mineral processing activities and ancillary facilities. The specific terms of reference are as follows:

a) Compile an inventory (identify, describe and, where possible, quantify) of the various waste streams to be generated by the project. This did not include the analysis of solid waste samples.
b) Briefly describe the processes giving rise to the waste streams and the anticipated volumes and tonnages of waste streams.
c) Identify and describe the possible impacts of any solid and liquid wastes on the quality of surface and groundwater.
d) Provide recommendations on the most feasible options for the disposal of solid and liquid wastes.
e) Describe the nature of hazardous waste likely to be associated with the project, paying particular attention to any material that might be regarded as radioactive, and make recommendations for the disposal and/or recycling of these materials.
f) Relate levels of any potentially toxic waste to recognised international standards, and ensure that any waste management strategy is in line with these standards.

Assumptions and information availability

Much of the information regarding the proposed development and quantitative data relating to waste streams on which this report was based was provided by the Client. It was assumed that the information that was provided was correct and valid. Importantly, at the time of preparing this report much of the detailed project information relevant to this waste specialist study was not available. In particular, information on the quantities of wastes to be produced and disposal plans for non-tailings wastes could not be provided.

This specialist report was subject to the following assumptions and limitations:

- Due to the remote location of the mine site, this report includes a recommendation for the proponent to develop a new landfill on the mine site for the disposal of general (non-
hazardous) waste from the development. At this early stage, no details are available on the potential location or specific design features of such a facility as these details are considered outside of the scope of this specialist study. However, the report does provide guidance on site selection criteria (including fatal flaws) and facility design features.

- Key impacts associated with the establishment and operation of a landfill site within or outside the project boundary are likely to relate primarily to water resources and air quality. Although potential impacts are identified in this specialist report, the significance of the impacts will need to be assessed by the relevant specialist.
- The specialist team did not visit the proposed project site. As such, all project-specific information was based on information supplied by client and was assumed to be accurate. All information on the local biophysical and social context was obtained from the scoping report (CES, July 2013).
- The impacts to air quality associated with the proposed mine are not covered but assessed in a separate air quality specialist report.
- The report includes a preliminary assessment of the waste-related impacts of the proposed development. Due to the lack of information on the quantity of non-tailings wastes or their management, the authors of this report have relied on estimates and international best practice management options. As a consequence, once further information about the waste streams becomes available it will be necessary to review the waste-related impacts and their associated significance ratings.

**Approach**

Prior to the assessment of the likely environmental impacts associated with the management of waste expected to be produced over the life of the project, it was necessary to understand the context of the operation. This included a review of the bio-physical and social context, the institutional capacity, legal framework and waste management infrastructure. Key legislation and international agreements and standards relevant to waste management for the Tete Iron Ore project development include the following documents:

- Environmental Act (Law 20/97) (1997)
- Regulation on Environmental Quality Standards and Effluent Emission Decree No. 18/2004 as amended by the Decree No. 67/2010
- Regulation on the process of EIA Decree No. 45/2004 as amended by Decree 42 of 2008
- Regulation on the Environmental Audit process Decree No. 32/2003
- Regulations on Waste Management, Decree No. 13/2006
- Regulation on the Management of Bio-Medical Waste Decree No. 8/2003

Information regarding the process, expected waste volumes and properties of the wastes was obtained directly from the client. Additional information was obtained from relevant reference sources. A life cycle assessment approach with a limited spatial scope was used to identify all key waste streams associated with the proposed project. The assessment covered waste streams during the construction, operation and decommissioning phases of the mine and pig iron production facility. Transport of the final product has not been considered.

For the purposes of this report, waste streams generated during the operational phase have been defined as either process wastes or non-process wastes. It is likely that the process and non-process waste streams will include both hazardous and general (non-hazardous) wastes.

A standardised impact assessment methodology was applied to assess the significance, both positive and negative, associated with the management of waste from the proposed development.
Results and conclusions

Based on the available project description and supplementary information sourced from a variety of sources, it was possible to make an assessment of the likely impacts associated with the management of waste streams from the proposed Tenge-Ruori iron project in Mozambique. This will, however, need to be reviewed once further detailed information on, in particular, management of process waste streams becomes available.

A total of 14 impacts were identified and of these, with mitigation, 11 were considered to be of LOW negative significance and two of MODERATE negative significance, after mitigation. One impact was considered beneficial and of Moderate significance with mitigation.

Summary of the wastes related environmental impacts for the Capitol Resources Iron Ore project

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temporal Scale</td>
<td>Spatial Scale</td>
<td>Severity of Impact</td>
</tr>
<tr>
<td>Issue 1: Disposal of waste rock and tailings (Operational phase)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Impact 1.1: Health and safety of employees and local communities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long Term</td>
<td>Localized</td>
<td>Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long Term</td>
<td>Localized</td>
<td>Slight</td>
</tr>
</tbody>
</table>

Issue 2: Spillage of Run of Mine while Trucking (Operational phase)

| Impact 2.1: Disruption of ecological function | | | |
| Without Mitigation | Long Term | Localized | Moderate | May Occur | MODERATE |
| With Mitigation | Long Term | Localized | Slight | May Occur | LOW |

Issue 3: Storage of process effluent in the process water pond (Operational phase)

| Impact 3.1: Pollution of soil and water resources | | | |
| Without Mitigation | Medium Term | Localized | Moderately Severe | Probable | MODERATE |
| With Mitigation | Long Term | Localized | Slight Severity | Probable | LOW |

| Impact 3.2: Risk to health and safety of employees | | | |
| Without Mitigation | Medium Term | Localized | Very Severe | Probable | HIGH |
| With Mitigation | Medium Term | Localized | Very Severe | May Occur | MODERATE |

Issue 4: Management and disposal of slag (by-product) (Operational phase)

| Impact 4.1: Contamination of land and water | | | |
| Without Mitigation | Long Term | Study Area | Moderate | May Occur | MODERATE |
| With Mitigation | Long Term | Study Area | Slight | Unlikely | LOW |

Issue 5: Management of non-process general and hazardous wastes (All phases)

| Impact 5.1: Pollution of land and water | | | |
| General (Non-hazardous) wastes | | | |
| Without Mitigation | Long term | Study area | Moderately Severe | Probable | MODERATE |
| With Mitigation | Long term | Study area | Slight | Probable | LOW |

<p>| Hazardous wastes | | | |
| Without | Permanent | District | Very Severe | Probable | HIGH |</p>
<table>
<thead>
<tr>
<th>Impact</th>
<th>Temporal Scale</th>
<th>Spatial Scale</th>
<th>Severity of Impact</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Moderate</td>
<td>May Occur</td>
<td>MODERATE</td>
</tr>
</tbody>
</table>

Impact 5.2: Nuisance impact (Production of odours, visual impact and attraction of pest and vermin)

Without Mitigation

- Long-term
- District
- Moderately Severe
- Probable
- MODERATE

With Mitigation

- Long-term
- District
- Slight
- Probable
- LOW

Issue 6: Disposal of domestic wastewater and sewage sludge (All phases)

Impact 6.1: Pollution of soil and water

Without Mitigation

- Long-term
- Study area
- Moderately Severe
- Probable
- MODERATE

With Mitigation

- Long-term
- Study area
- Slight
- Probable
- LOW

Impact 6.2: Health impacts to employees and communities

Without Mitigation

- Long-term
- District
- Severe
- Probable
- MODERATE

With Mitigation

- Long-term
- District
- Slight
- Probable
- LOW

Impact 6.3: Nuisance impacts (odour and flies)

Without Mitigation

- Short-term
- Study area
- Moderately Severe
- Probable
- MODERATE

With Mitigation

- Short-term
- Study area
- Slight
- Probable
- LOW

Issue 7: Disposal of run-off / storm water (All phases)

Impact 7.1: Pollution of land and water

Without Mitigation

- Long-term
- Study area
- Moderately Severe
- Probable
- MODERATE

With Mitigation

- Long-term
- Study area
- Slight
- Probable
- LOW

Issue 8: Regional waste profiles and community awareness (Construction and Operational Phases)

Impact 8.1: Local knowledge of waste management practices

Without Mitigation

- Permanent
- District
- Slightly beneficial
- Definite
- LOW (+ve)

With Mitigation

- Permanent
- District
- Beneficial
- Definite
- MODERATE (+ve)

Impact 8.2: Change to waste profiles in the local communities

Without Mitigation

- Permanent
- District
- Moderately Severe
- Definite
- MODERATE

With Mitigation

- Permanent
- District
- Slight
- Definite
- LOW

Recommendations

It is recommended that all waste streams should be managed according to the waste management hierarchy and, as a minimum, according to Decree 13/2006, of 15 July: Regulation of Waste Management. This specifies that wherever possible, production of wastes should be prevented or minimised at source. Where prevention or further minimization is not possible, wastes should be re-used, recycled and then disposed of responsibly so as to minimise impacts to the environment. Further guidance on the management of waste streams is provided in the IFC General EHS Guidelines (2007) and the IFC EHS Guidelines for Mining (2007). In the event that there are no national standards available, the proponent must comply with internationally recognised standards developed by international organisations such as the IFC. In the case where there are several...
standards available for use, the proponent must provide justification for the choice of use, other than the use of the most stringent.

Due to the local situation as per the remote location of the project site and relevant legislation, it is recommended that the proponent establish a general (non-hazardous) waste disposal facility on the site. The report provides detailed guidance on the selection of candidate sites for the on-site general waste landfill.

Alternative options will need to be considered for the management and disposal of hazardous wastes. These would be to either develop a dedicated and specially-designed hazardous waste cell within the new on-site landfill or, alternatively, to construct a bunded and secure facility for temporary storage of hazardous waste on site until such time as it can be transported off-site for safe disposal. Although the only existing hazardous waste landfill in Mozambique is located in Maputo, there is an indication that new hazardous waste disposal facilities are in the process of being developed closer to the project site, including one in Tete Province, and disposal of hazardous waste at that facility should be regarded as the preferred option.
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<th>MEANING</th>
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<tbody>
<tr>
<td>ARD</td>
<td>Acid Rock Drainage</td>
</tr>
<tr>
<td>BPEO</td>
<td>Best Practicable Environmental Option</td>
</tr>
<tr>
<td>CES</td>
<td>Coastal &amp; Environmental Services</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>DPCAs</td>
<td>Provincial Directorates for the Coordination of Environmental Affairs</td>
</tr>
<tr>
<td>EA</td>
<td>Environment Act</td>
</tr>
<tr>
<td>EHS</td>
<td>Environmental, Health and Safety</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
<tr>
<td>EIR</td>
<td>Environmental Impact Report</td>
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<td>ESHIA</td>
<td>Environmental, Social &amp; Health Impact Assessment</td>
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<tr>
<td>FAO</td>
<td>Food and Agriculture Organisation</td>
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<tr>
<td>GIIP</td>
<td>Good International Industry Practice</td>
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<tr>
<td>ICRC</td>
<td>International Committee of the Red Cross</td>
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<tr>
<td>IFC</td>
<td>International Finance Corporation</td>
</tr>
<tr>
<td>IMO</td>
<td>International Maritime Organisation</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicators</td>
</tr>
<tr>
<td>LC</td>
<td>London Convention</td>
</tr>
<tr>
<td>LIMS</td>
<td>Low Intensity Magnetic Separation</td>
</tr>
<tr>
<td>MICOA</td>
<td>Ministry for the Coordination of Environmental Affairs</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material Safety Data Sheets</td>
</tr>
<tr>
<td>NEMP</td>
<td>National Environmental Management Programme</td>
</tr>
<tr>
<td>PS</td>
<td>Performance Standards</td>
</tr>
<tr>
<td>SPDI</td>
<td>District Planning and Infrastructure Services</td>
</tr>
<tr>
<td>tpa</td>
<td>tons per annum</td>
</tr>
<tr>
<td>TSF</td>
<td>Tailings Storage Facility</td>
</tr>
<tr>
<td>VIP</td>
<td>Ventilated Improved Pit</td>
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INTRODUCTION

1.1 Project background

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Much of the information regarding the proposed development and quantitative data relating to waste streams on which this report was based was provided by the Client. It was assumed that the information that was provided was correct and valid. Importantly, at the time of preparing this report much of the detailed project information relevant to this waste specialist study was not available. In particular, information on the quantities of wastes to be produced and disposal plans for non-tailings wastes could not be provided.

This specialist report was subject to the following assumptions and limitations:

- Due to the remote location of the mine site, this report includes a recommendation for the proponent to develop a new landfill on the mine site for the disposal of general (non-
hazardous) waste from the development. At this early stage, no details are available on the potential location or specific design features of such a facility as these details are considered outside of the scope of this specialist study. However, the report does provide guidance on site selection criteria (including fatal flaws) and facility design features.

- Key impacts associated with the establishment and operation of a landfill site within or outside the project boundary are likely to relate primarily to water resources and air quality. Although potential impacts are identified in this specialist report, the significance of the impacts will need to be assessed by the relevant specialist.
- The specialist team did not visit the proposed project site. As such, all project-specific information was based on information supplied by client and was assumed to be accurate. All information on the local biophysical and social context was obtained from the scoping report (CES, July 2013).
- The impacts to air quality associated with the proposed mine are not covered but assessed in a separate air quality specialist report.
- The report includes a preliminary assessment of the waste-related impacts of the proposed development. Due to the lack of information on the quantity of non-tailings wastes or their management, the authors of this report have relied on estimates and international best practice management options. As a consequence, once further information about the waste streams becomes available it will be necessary to review the waste-related impacts and their associated significance ratings.

1.4 Structure of the report

Chapter 1 – Introduction
Chapter 2 – Project Description
Chapter 3 – Overview of waste management in Mozambique
Chapter 4 – Methodology
Chapter 5 – Waste Classification and Quantification
Chapter 6 – Assessment of Potential Environmental Impacts
Chapter 7 – Conclusions and Recommendations
References
Appendix

1.5 Study team

The following team members were involved in the specialist study:

**Dr Kevin Whittington-Jones** (Project Leader and Report Review)

Kevin holds a PhD in Environmental Biotechnology and an MSc in Zoology (marine ecology) and is a Director at CES. His professional interests include environmental business risk, management systems, waste management and climate change. Prior to joining CES he held various academic posts at Rhodes University, including that of Senior Lecturer at the Rhodes Investec Business School. Kevin has undertaken environmental work at many of the ports in South Africa, including environmental risk assessments, a climate change risk assessment, strategic environmental assessments and an integrated waste management plan. Kevin has also been involved in a number of industrial EIA projects within South Africa and internationally, both as Project Manager and as a waste management specialist. More specifically, he has conducted specialist waste management studies for various heavy mineral, copper and graphite mining projects (Egypt, Madagascar, Mozambique and Malawi), manganese smelters (Kalogadi and Exxaro, both in South Africa), biofuel & biomass projects (Sierra Leone, Liberia and Mozambique), a brewery (Mozambique) and the Rabai Power Station (Kenya). He is currently managing the EIAs for large-scale developments in Mozambique and is assisting Kenmare Resources’ heavy mineral mine to comply with the requirements of the IFC Performance Standards.
2 PROJECT DESCRIPTION

2.1 Introduction

This Chapter of the report provides a brief overview on the elements of the proposed Capitol Resources Iron Ore project in Mozambique that will give rise to hazardous and non-hazardous solid and liquid wastes. This includes waste generated as a result of direct project process and non-process related activities. Inclusion of a detailed project description was not considered necessary as this will be provided elsewhere in the main Environmental Impact Report (ESIR).

2.2 Project context

2.2.1 Biophysical context

Mozambique is located along the eastern coast of southern Africa between 10°27' and 26°52' South and 30°12' and 40°51' East. It covers a surface area of 799 380 km² and is bordered by South Africa, Swaziland, Zimbabwe, Zambia, Malawi and Tanzania (Ribeiro and Chauque; 2010). This project will be located in Tete Province north of the provincial capital, Tete, in the Chiúta and Moatize districts.

The scoping report contains a relatively detailed description of the local biophysical and social context of the project. As the potential significance of waste-related impacts is frequently context-specific, it is considered important to review some of the key features, in particular, those related to topography, water resources and local communities. The associated references are also provided in the scoping report and are not repeated here.

The project area exhibits a predominately flat topography with key project elements located in a wide and flat valley. The only exceptions are the Tenge Ruoni hills that include Mt Tenge, Ruoni North hill and Ruoni South hill.

The climate of the area is considered sub-tropical, with a mean annual rainfall of 1000mm. January is traditionally the wettest month, with a mean rainfall of 229mm while rainfall in the driest months of August and September are 6mm and 5mm, respectively. The temperature varies from a mean annual maximum of 33.6°C in summer to a mean annual minimum of 14.5°C in winter.

Geologically, the area is characterised by gabbro-anorthosites of the Tete Suite. The rocks of the suite are mainly composed of iron-titanium oxides. Wide spread and locally thick eluvial deposits cover the surface of the plateau with boulders and blocks formed from the more resistant types of rocks of the suite. Geochemistry assays indicate the potential for Acid Rock Drainage (ARD), where acid forming rock is exposed to air and water and seeps into the environment, given the presence of sulfur; although it is not known if the sulfur occurs as pyrite (acid-generating) or sulfate (non-acid generating). According to the scoping report, soils, of varying depth (10cm to greater than 50cm), include those associated with the river (fluvial soils) and old floodplain. The chemical profiles of the soils are variable but gypsum accumulations have been identified in certain areas.

The Tenge-Ruoni project area is located in the Revuboe River catchment area. There are two major watercourses located within, or in the vicinity of the project area; the Revuboe River and the Nhambia River (Figure 2.1). The Revuboe River flows from north to south, bisecting the Tenge-Ruoni deposit and eventually discharging into the Zambezi River further south. The Nhambia River connects with the Revuboe River downstream of the mine site.

There are two aquifers in the project area; an upper aquifer in weathered material, and a lower aquifer in fractured rock. Groundwater emerges in lower lying areas such as soaks or springs and generally flows down-gradient to the Revuboe River and its tributaries. Depths to groundwater range from 2.6 m to 85 m below ground level.
2.2.2 Social context

Tete Province is located in the north-west of Mozambique and is composed of 13 districts, including Chiúta and Moatize, which are of relevance to the project.

Demographics

Population and Housing
The district of Chiúta has a total population of 89,595 inhabitants and a population density of 12.6 inhabitants per km². The district of Moatize is much more populated than Chiúta, with a total population of 292,341 inhabitants and a population density of 34.7 inhabitants per km².

The predominant housing structures in the districts are mud (wattle and daub) huts with thatched roofs. The Moatize district does have a higher percentage of houses built with durable materials such as brick and zinc roof sheets in comparison to Chiúta (INE, 2013 and INE, 2013b).

Education and Employment
There are five primary schools in the project area, with one school offering the full seven grades of primary school, whilst the remaining four schools only offering the first three grades. Very few of the children in the area attend secondary school and there is a low level of literacy.

The employment rate in the project area is a low of 17%. The main forms of economic activity include subsistence farming and unskilled labour. Agriculture, including fishing and forestry, and animal husbandry are the main livelihood strategies adopted by households. On average the Chiúta household average monthly income is MZM 5,645 per month (about USD$181) against MZM 4,767 (about USD$153) earned by the Moatize households.
Access to services

Water and Electricity
The population of the Chiúta district have limited access to water and electricity, with less than 1% of the population using some form of electricity and majority of the population relying on rivers as a water source (INE, 2013). Seven percent of the Moatize district population has access to electricity and two thirds of the population access their water from unprotected sources, while the other third secure protected water from protected wells, tap water or hand pumps (MAE, 2005b).

Health and Sanitation
There are limited healthcare facilities in close proximity to the project area. There are no emergency services and medical services are not free. There is one healthcare post in Muchena providing basic medical services and thee Red Cross First Aid Care Units within close proximity to the project area. Furthermore, there are very few improved sanitation facilities in the area. Majority of the sanitation facilities are traditional pit latrines.

2.3 Project overview

2.3.1 General overview
This project will involve the extraction of iron ore from the Tenge ore body using conventional drilling and blasting techniques over a period of up to 23 years. Alternative scenarios include mining of additional pits, specifically Ruoni North and Ruoni South, but these scenarios are not being considered further in this specialist report. Key process-related infrastructure, including the waste rock dump, tailings storage facility and beneficiation plant and pyrometallurgical plant, are all located in close proximity to the Tenge pit on the eastern side of the Revuboe River (Figure 2.2).

This ore will then be processed, using a combination of crushing, screening and magnetic separation to yield magnetic concentrate. This will then undergo further processing in a pre-reduction and smelting facility. The final product (pig iron) will be transported from the mine site via road and possibly rail to Moatize. The product will then be transported to the ports of Beira and Nacala for export to the international market. Details of the production process are provided in Section 2.3.2.

Water for the process, estimated to be in the region of 1500 ML (million litres) per year, will either be extracted from the Revuboe River or from ground water and is likely to require treatment. All power will be supplied via the national grid.

In terms of employment, it is estimated that 2000 - 3000 personnel will be required for the construction phase and approximately 500 personnel for the operational phase.
Figure 2.2: Tete Iron Ore Project preliminary layout
2.3.2 Process description

Initial beneficiation

Currently, two beneficiation process options are being considered (Figure 2.3). Option 1 involves passing the ore through a series of dry crushing and screening steps and, subsequently, magnetic cobbled and pre-reduction classification, resulting in the production of magnetic product and non-magnetic tailings. Option 2 is similar to Option 1 but the magnetic product is subjected to further classification and wet separation using low-intensity magnetic separation (LIMS). The resultant tailings are then thickened prior to disposal at the TSF while the product concentrate is dewatered and stored for further processing.

Any decant water from the TSF is transferred to a storage dam for use within the process.

Pig iron production

The iron ore product from the initial beneficiation process will be further refined in a dedicated pre-reduction and smelting facility. In this process, the iron ore product (along with dolomite and coal) will be pre-reduced in a multi-hearth furnace and rotary kiln using local thermal coal. Depending on findings of further test work to be carried out during the detailed feasibility study, a coal preparation plant could be added to the process (e.g., coal washing). Hot off-gas and combustion air from the furnace and kiln (respectively) will be directed to a waste heat boiler where it is the intention to produce electrical energy, depending on feasibility of this process. A pre-reduced iron ore and residual carbon product will then be fed to a melting furnace to produce molten forms of pig iron product, a titanium rich slag and a vanadium slag as by-products. The pig iron production process is outlined in Figure 2.4.

2.3.3 Auxiliary (non-process) facilities

The project description indicates that auxiliary facilities will include the following:

- A camp providing accommodation for the 500 workers of the mine
- Fuel storage facilities
- Parking and repair facilities for the mining vehicles and machinery
- Laydown areas

In addition, developments of this nature are also expected to include the following that will have implications for management of wastes:

- A construction camp for up to 3000 workers
- Pump houses
- Water reservoirs for storage of production and potable water
- Water treatment plant(s)
- Offices and administration buildings
- Storage for equipment, spares and consumables;
- Ablution facilities and associated sewage treatments plants / septic tanks;
- A mess/kitchen
- Laboratories;
- Temporary hazardous waste storage facility;
- Landfill site
- Product sheds
- A clinic and various first aid stations.
Figure 2.3: Proposed process flow sheet for the Tete Iron Project (combined wet/dry process option)
Figure 2.4: Tenge-Ruoni pig iron reduction process flow sheet for the Tete Iron Project
3 OVERVIEW OF WASTE MANAGEMENT IN MOZAMBIQUE

3.1 Introduction

Before characterizing waste streams or considering alternatives for their management and disposal, it is important to consider the relevant institutional arrangements, legislative framework and existing infrastructure. Apart from consideration of the broader Legislation, Policies and Standards related to the protection of environmental and human health, it is also necessary to consider the definitions of waste, the goals and objectives of applicable waste management strategies and policies, the desirability of recycling and reuse, and any permitting requirements.

When assessing the management options for solid waste streams, it is necessary to review the institutional capacity for waste management in the country of the proposed project and to also consult the country-specific guidelines for identification of general and hazardous wastes.

3.2 Definition of waste

The Regulation of Waste Management Decree 13/2006 of 15 July, Mozambique, defines waste “as any substances or objects that are discarded, intended to be discarded or are required to be discarded by law”. The regulation classifies waste into two categories hazardous and non-hazardous wastes. Defining hazardous waste as “waste that exhibits characteristics of risk for their being ignitable, explosive, corrosive, toxic, infectious or radioactive, or for exhibiting any other forms that could pose a hazard to the lives or health of persons and other living beings and to the quality of the environment” and that it contains any of the characteristic listed in Annex III of the regulation. Non-hazardous waste is defined as “the waste that contains no characteristics of risk” and does not contain any of the characteristics listed in Annex III of the regulation. The definition of hazardous waste provided in the regulation is in accordance with the Annexes I, II and III of the Basel Convention.

As many of the large-scale development projects on the African continent are financed to some degree by international lending agencies, it is also important to consider the International Finance Corporation’s definition of waste. According to the Section 1.6 (Environment: Waste Management) of the IFC EHS Guidelines (30 April 2007), waste is defined as, “any solid, liquid or contained gaseous material that is being discarded by disposal, recycling, burning or incineration”. It can be:

- A by-product of a manufacturing process, or;
- An obsolete commercial product that can no longer be used for intended purpose and requires disposal.

The Guideline document goes on further to differentiate between solid (non-hazardous) wastes and hazardous wastes (Table 3.1). The classification of waste is discussed in more detail in section 5 of this report.

3.3 Institutional framework

Prior to reviewing the legislative framework and the implications thereof for the proposed project, it is important to review the roles and responsibilities of various authorities within the country.

In terms of Article 24 of the EIA Regulations (as amended), the Ministry for the Coordination of Environmental Affairs (Ministério para a Coordenação da Acção Ambiental (MICOA)) is responsible for making regular inspections of construction sites for new activities and the operations of existing facilities. In a complex situation or where environmental conditions justify it, MICOA is mandated to request an environmental audit to be conducted. MICOA has two broad domains of responsibility (1) implementing the National Environmental Management Plan and associated environmental policy and legislation and (2) coordinating with other ministries on environmental matters to integrate environmental aspects into their projects, programmes and policies. MICOA is organised into the following five National Directorates:

- Environmental Impact Assessment (including waste management);
• Environmental Management;
• Land Planning;
• Promotion of Environmental Awareness; and
• Planning and Studies.

Table 3.1: Definition of solid (non-hazardous wastes) and hazardous wastes according to the IFC General EHS Guidelines (2007)

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Definition and Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid (non-hazardous) wastes</td>
<td>Examples of such waste include domestic trash and garbage; inert construction/demolition materials; refuse such as metal scrap and empty containers (except those previously used to contain hazardous materials which should, in principle, be managed as a hazardous waste); and residual waste from industrial operations, such as boiler slag, clinker, and fly ash.</td>
</tr>
<tr>
<td>Hazardous wastes</td>
<td>Share the properties of a hazardous material (e.g. ignitability, corrosivity, reactivity, or toxicity), or other physical, chemical, or biological characteristics that may pose a potential risk to human health or the environment if improperly managed. Wastes may also be defined as “hazardous” by local regulations or international conventions, based on the origin of the waste and its inclusion on hazardous waste lists, or based on its characteristics. Sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility, and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial operations needs to be evaluated on a case-by-case basis to establish whether it constitutes a hazardous or a non-hazardous waste.</td>
</tr>
</tbody>
</table>

In order to discharge its mandate more effectively, and in line with the government’s decentralisation policy, MICOA has been establishing an increasing institutional presence at lower government levels since 1995. At the provincial level, MICOA is represented by the Provincial Directorate for the Coordination of Environmental Affairs (Direcção Provincial para a Coordenação da Acção Ambiental (DPCAs)). At district level, MICOA’s representation is through the District Planning and Infrastructure Services (Serviços do Distritais de Planeiamento e Infraestruturas (SDPI)) under the Ministry of Public Works. This department is responsible for handling issues related to land use planning, as well as any issues related to environmental protection. DPCAs have been set up in 10 of the 11 provinces of Mozambique except Maputo-City represented by the National Directorate of Environmental Impact Assessment. The role of the DPCAs is, in principle, to facilitate the local implementation of centrally developed environmental legislation, policies and programmes, including the EIA Regulations and Guidelines. Most provincial government structures include departments of environmental management and some (e.g. those in Nampula and Cabo Delgado Provinces) have separate EIA departments. Table 3.2 shows potentially applicable sector waste legislation.
### Table 3.2: Institutional responsibilities for waste management in Mozambique

<table>
<thead>
<tr>
<th>Sector</th>
<th>Primary Agency</th>
<th>Title and Date of Document</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Management</td>
<td>MICOA</td>
<td>Decree No. 13/2006, of 15 June, Regulations on Waste Management</td>
<td>Article 10 of the Decree provides that MICOA will issue a Waste Management Licence for scheduled waste management activities contained in Annex VI (Disposal activities) and VII (Recycling / Recovery Facilities). The License will be valid for a period of 5 years after which it needs to be reviewed. Applications for renewal must be submitted at least 180 days before the expiry date of the licence.</td>
</tr>
<tr>
<td>Waste Management</td>
<td>District Government (Rural areas)</td>
<td>Decree No. 13/2006, of 15 June, Regulations on Waste Management</td>
<td>In terms of waste management it is the responsibility of district governments in the areas under their jurisdiction to establish the means, procedures for collection and means of collection, transportation, disposal and treatment of waste, particularly, hospital and other toxic waste; Establish fees, render services in collection, removal, transportation, disposal and treatment of waste, including hospital and other toxic waste; License facilities involved in hazardous and toxic waste management.</td>
</tr>
<tr>
<td>Waste Management Plan</td>
<td>Each municipality (i.e. only urban)</td>
<td>Municipality Law No. 2/97</td>
<td>Local municipality ensures basic sanitation and quality of life within their municipalities. The Law sets out municipal responsibility to develop programmes for ecological protection and procedures for the removal of solid waste, and the treatment and disposal of solid residues, including medical and hazardous waste.</td>
</tr>
<tr>
<td>Transport of Hazardous Waste</td>
<td>MICOA</td>
<td>Decree No. 13/2006, of 15 June, Regulations on Waste Management</td>
<td>Hazardous waste may only be moved to the exterior of the facilities of the producing entity by transport operators or transporters duly certified by the MICOA, for collection and removal of such waste.</td>
</tr>
<tr>
<td>Licensing and auditing of Landfill Sites</td>
<td>MICOA</td>
<td>Decree No. 13/2006, of 15 June, Regulations on Waste Management</td>
<td>All public or private entities carrying out activities related to solid waste management should prepare their waste management plan, prior to entering into business, which should contain at least, information required in for landfill operation and submit to MICOA for approval.</td>
</tr>
<tr>
<td>Permitting of Waste Management Facilities</td>
<td>MICOA</td>
<td>Decree No 45 of 2004 EIA Regulation as amended by Decree 42 of 2008</td>
<td>MICOA is responsible for the environmental permitting of waste management facilities as designated in Category A listed activities contained in Decree No 45 of 2004 (EIA Regulations) viz. facilities for ‘treatment and disposal of solid and liquid waste : a) Places for disposal of municipal waste with a load greater than 500 tonnes per day; b) Storage, transportation, treatment and disposal of dangerous industrial waste; c) Facilities for the disposal / treatment of storm water / sewage with capacity for more than 150 000 inhabitants.</td>
</tr>
</tbody>
</table>

### 3.4 Relevant National Environmental Legislation, Policies and Standards

A number of Mozambican laws will apply to this project, and the following section provides a brief summary of those that have bearing on the management of wastes. The summary is not exhaustive at this stage, and a more detailed review or the most recent relevant regulatory instruments will be undertaken during the detailed EIA phase of the assessment.
It is apparent that the sound management of solid and liquid waste is an area of focus of the local government in Mozambique and that a sound understanding of the relevant Policies and Acts is important for any developer wishing to operate within Mozambique. An understanding of this legal framework is also essential when evaluating options for the management of wastes. The following documents have bearing on the management of wastes in Mozambique:

- Environmental Act (Law 20/97) (1997)
- Regulation on Environmental Quality Standards and Effluent Emission Decree No. 18/2004 as amended by the Decree No. 67/2010
- Regulation on the process of EIA Decree No. 45/2004 as amended by Decree 42 of 2008
- Regulation on the Environmental Audit process Decree No. 32/2003
- Regulations on Waste Management, Decree No. 13/2006
- Regulation on the Management of Bio-Medical Waste Decree No. 8/2003

### 3.4.1 The Constitution of the Republic of Mozambique (2004)

The Constitution is the supreme law of the land and any act or conduct inconsistent with it is invalid and will have no force of law. The Constitution addresses matters relating to the environmental protection and quality of life in Articles 45, 81, 90, 98, 102 and 117. Article 90, which is part of Chapter V (Economic, social and cultural rights and duties) of Title III (Fundamental rights, duties and liberties), gives the people of Mozambique the right to live in a balanced environment free of contamination. It commits ‘the State and local authorities, in collaboration with other appropriate partners, to adopt policies for the protection of the environment through appropriate waste management practice and care for the rational utilisation of all natural resources’.

### 3.4.2 Environmental Act (Law 20/97) of 1 of October 1997

Many of the requirements relating to the management of waste within Mozambique are documented in the Environment Act (Law 20/97 of 1 October 1997). This Act was one of the first regulatory tools developed by the Mozambican Government to ensure that waste does not pollute the natural environment or effect the social environment. The law provides a general framework for environmental protection, including the management of waste. The purpose of the Law is to, “define the legal basis for the proper use and management of the environment and its elements in order to establish a system of sustainable development” in the country.

According to the Environment Act (Law 20/97 of 1 October 1997), any waste and effluent related activity with a significant impact on the environment requires an environmental license. The Environment Act (EA) also states that the environmental license shall be subject to specific regulations on the process of EIA study (approved EIA decree No. Decree 45/2004 as amended by Decree 42/2008).

The Environmental Law of 1997 imposes strict liability on persons who cause material damage to the environment. The State has the right to assess the damage, fix the amount of compensation and to take counter measures at the expense of the person causing the damage. In addition to the above, provided in Table 3.3 (below) are the sections of the Environmental Law of 1997 that are particularly relevant to waste management and the prevention of pollution of the environment in Mozambique.
Table 3.3: Sections of Mozambique’s Environment Law that have relevance to the management of wastes within the country

<table>
<thead>
<tr>
<th>Section #</th>
<th>Article #</th>
<th>Sub Article #</th>
<th>Stipulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>III: Environmental Pollution</td>
<td>9: Prohibition against pollution</td>
<td>1</td>
<td>The production, deposit in the soil or sub-soil, emission into water or the atmosphere of any toxic or pollution substance as well as the practice of any activities which accelerate the erosion, desertification, deforestation or any form of environmental degradation that are outside of the legally established limits is not permitted in the national territory.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>The importation into the national territory of toxic residues or wastes is expressly prohibited, except under the terms that would be established in specific legislation.</td>
</tr>
<tr>
<td></td>
<td>10: Environmental Quality Standards</td>
<td>2</td>
<td>In the definition of the environmental quality standards, rules and time limits shall be established for agricultural and industrial processes including machinery and methods of transport to adopt the appropriate technology and procedures in order to neutralise or prevent the emission of polluting substances.</td>
</tr>
<tr>
<td>IV: Special Measures for Environmental Protection</td>
<td>14: Erection of Infrastructures</td>
<td>1</td>
<td>The erection of residential or other infrastructures and the deposit of waste and used materials which, by virtue of their size, nature or location, would provoke a significant negative impact on the environment are prohibited.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>The prohibition referred to in the previous number is applicable in particular to coastal zones, zones threatened by erosion and desertification, wetlands, environmental protection zones and other ecologically sensitive zones.</td>
</tr>
<tr>
<td>V: Prevention of Environmental Damage</td>
<td>18: Environmental Audits</td>
<td>1</td>
<td>All activities which on the date this law enters into force are operating without the application of appropriate technologies or procedures and as a consequence, result or could result in damage to the environment shall be subjected to an environmental audit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>The operators of the activities shall be responsible for the costs which result from the repair of environmental damage which may be determined by the audit.</td>
</tr>
<tr>
<td>VII: Exercise of Economic Activities</td>
<td>26: Strict Liability</td>
<td>1</td>
<td>Any person who causes material damage to the environment or who provokes the temporary or definitive standstill of economic activity as a result of the practice of especially dangerous activities, shall, regardless of intent and notwithstanding compliance with the law, be obligated to indemnify the injured parties.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>The government shall have the power and authority to evaluate the seriousness of the damage and to assess the amount of compensation. The amount of compensation shall be fixed by environmental expert testimony and proof.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Whenever circumstances so require, the State shall take the necessary measures to prevent, contain or eliminate any grave damage to the environment. The State shall have the right to seek compensation for these costs incurred.</td>
</tr>
</tbody>
</table>
3.4.3 National Environmental Management Programme (NEMP), 1995

The Ministry for Co-ordination of Environmental Affairs (MICOA) approved a National Environmental Management Programme (NEMP) in 1995. This is a policy document outlining the priorities for environmental management and sustainable development in the Country. The underlying goal of Mozambique’s environmental legislation is the protection of human and environmental health and, importantly, the legislation promotes the governing of Polluter Pays Principle, Preventive and Corrective Action Principle, and the Precautionary Principle.

3.4.4 Regulation on Environmental Quality Standards and Effluent Emission Decree No. 18/2004 of 2 June 2004 amended by the Decree No. 67/2010

The Regulation on Environmental Quality Standards and Effluent Emission (Decree No. 18/2004) establishes the environmental quality standards and permissible limits for effluent and emission discharge by industries. The purpose of these Regulations is to establish standards for environmental quality and effluent emissions, aiming at the control and maintenance of the admissible levels of concentration of pollutants in the environment. The provisions of these Regulations are applicable to all new public and private activities that may affect the environment directly or indirectly. Existing factories and processing plants have to adapt their equipment to ensure compliance within five years from the date of publication of the Regulations. Article 6 of the Regulations requires them to be reviewed (and updated) every five years, unless the obligations deriving from an international convention require more urgent action. The Regulations cover air quality (Chapter II), water quality (Chapter III), soil quality (Chapter IV), and noise (Chapter V). Contained in its annexes are Annexes IA and IB deals new standards of air quality, atmosphere polluting agents and parameters for carcinogenic Inorganic and Organic agents (as amended by Decree No 67 of 2010), Annex II - Emission standards for gaseous pollutants by Industries, Annex III – Standards of Emission of Liquid Effluents by Industries, Annex IV – Standards of Emission of Domestic Liquid Effluents, Annex V –lists potentially harmful chemical substances and Annex VI - Manual for Classification, Quantification, Interpretation of Laboratory Analysis of Soil and Water. According to the amendment regulations 67 of 2010, MT50 thousand to MT500 thousand is required as tax payment for emission of special permission. In addition, non-compliance with any of the pollution standards set out in Decree No. 18/2004 as amended or failure to report exceedances is punishable with a fine of between MT1 million to MT10 million.

The specific permissible Mozambican discharge limits for various pollutants within a sewage effluent stream are compared to those required by the IFC and AfDB (Appendix A), while those for mining liquid effluent are provided in Appendix B. Where there is a difference in the specific limits for a particular parameter, it is proposed that the most stringent be adopted.

3.4.5 Regulation on the process of Environmental Impact Assessment Decree No. 45/2004 as amended by Decree 42 of 2008

The regulation states that one of the key instruments for environmental management is the process of ESHIA, which aims to mitigate the negative impacts that certain projects of public and private sectors can cause to the natural and socio-economic environment, by conducting environmental studies before the project starts. It defines the process of environmental impact assessment, environmental studies, required public participation process, the process of review studies, the draft decision process feasibility and environmental issue and license. It is applicable to all public and private activities with direct or indirect influence on the environmental components.

The proponent has the responsibility to ensure that the proposed activities and the ESHIA process conform to the requirements of this regulation. The proponent is obliged to request an environmental license and perform the ESHIA process in support of the application in accordance with this Regulation and an environmental license must be obtained from the MICOA. Environmental Licences for all activities are valid for a period of five years, renewable for an equal period and application for renewal has to be submitted at least 180 days before the licence expires (Amendment Decree 42 of 2008).
3.4.6 Regulation on the Environmental Audit process Decree No. 32/2003 of 12 August

The Regulation on the Environmental Audit Decree 32/2003 defines an environmental audit as a tool for objective and documented management and systematic assessment of the management system with relevant documentation in place to ensure the protection of the environment. It aims to assess the performance of operational processes and working with the environmental management plan, including environmental legal requirements enforced and approved for a particular project.

3.4.7 Regulation of Waste Management Decree No. 13/2006 of 15 June

The Regulation of Waste Management (Decree No. 13/2006) is applicable to all individuals or collective bodies, public or private, involved in waste management and its objective is the establishment of norms relative to generation, disposal on soil and underground, dumping into water or to the atmosphere, of any toxic or polluting substances, as well as the carrying out of polluting activities that accelerate degradation of the environment, with view to preventing or minimizing the negative impacts on human and environmental health.

The Article 9 of the Regulation of Waste Management (Decree 13/2006), requires the producers of waste to minimize the production of their waste and the details of how to achieve waste minimization should be documented by the company. In addition to that, the Environmental Law 20/97 imposes strict liability on people who contribute to environmental degradation. The government has the responsibility to determine the amount for compensation and the person causing environmental degradation is responsible to pay the amount needed to rehabilitate the affected environment. The provision does not relate to hazardous wastes only. On the other hand, according to, the General Guideline for EIA, proponents are obliged to present details of the wastes and their management in the EIA report.

3.4.8 Regulation on the Management of Bio-Medical Waste Decree No. 8/2003 of 18 February

Decree No. 8/2003 defines bio-medical wastes as those emanating from medical facilities including veterinaries, treatment and medical research facilities. The regulation is applicable to health institutions, industries and individuals who produce and manage the disposal of bio-medical waste. It establishes the rules applicable to the management of medical waste, serving to protect the health and safety of healthcare workers and the general public as well as to minimize the impact of bio-medical waste on the environment.

According to the Bio-medical waste Decree No. 8/2003, bio-medical waste can only be transported off-site by operators licensed by MICOA and large quantities of waste pharmaceuticals should be returned to suppliers. The licensing of medical waste transporters by MICOA is done in coordination with the Ministry of Health which is responsible for the training and capacity development of medical waste transporters.

3.5 Relevant International Standards and Guidelines

There are a number of International Conventions and Guidelines that are of relevance to the project because they have been ratified by the Government of Mozambique. These relevant guidelines and conventions are discussed below.

3.5.1 Basel Convention

Mozambique is a signatory to the Basel Convention (accessed on the 13th of March, 1997), which is the Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal. This convention is highly relevant to the management of hazardous waste within Mozambique.
The main objectives of the Basel Convention are the reduction of the production of hazardous waste and the restriction of trans-boundary movement and disposal of such waste. It also aims to ensure that any trans-boundary movement and disposal of hazardous waste, when allowed, is strictly controlled and takes place in an environmentally sound and responsible way. Its scope of application covers a wide range of wastes defined as “hazardous wastes” based on their origin and/or composition and their characteristics (Article 1 and Annexes I, III, VIII and IX), as well as types of wastes defined as “other wastes” (household waste and incinerator ash; Article 1 and annex II).

In particular, the convention prohibits the trans-boundary movement of wastes and is applicable to wastes that belong to the following categories:

- Hazardous wastes that are subject to trans-boundary movement and they include
  a. Wastes that belong to any category contained in Annex I, unless they do not possess any of the characteristics contained in Annex III of the Convention; and
  b. Wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the legislation of Mozambique for export, import or transit.
- Wastes that belong to any category contained in Annex II that are subject to trans-boundary movement shall be “other wastes” for the purposes of this Convention.
- Wastes which, as a result of being radioactive, are subject to other international control systems, including international instruments, applying specifically to radioactive materials are excluded from the scope of this Convention.
- Wastes which derive from the normal operations of a ship, the discharge of which is covered by another international instrument, are excluded from the scope of this Convention.

For the purpose of this Convention, any trans-boundary (export and import) movement of the described wastes without due authorization by the relevant Mozambican authority is deemed illegal. It should be noted that the illegal trafficking of wastes also applies to damage due to an incident occurring during an authorized trans-boundary movement of hazardous wastes and their disposal. Decree No. 13/2006, of 15 June, Regulations on Waste Management, designates MICOA as the competent Mozambican authority for the approval of transport of hazardous waste. According to the Basel Convention Fact sheet of 2011, Mozambique has no legislation that restricts the export (including the transit) of hazardous wastes and other wastes for final disposal or recovery.

### 3.5.2 Bamako Convention

Mozambique is a signatory to the Bamako Convention (acceded on 5th February, 1999), which is the Convention on the ban of the import into Africa and the control of trans-boundary movement of hazardous wastes within Africa. The requirements of this Convention are similar to those of the Basel Convention.

Impetus for the Bamako Convention arose from the failure of the Basel Convention to prohibit trade of hazardous waste to less developed countries, and from the realization that many developed nations were exporting toxic wastes to Africa. Though the Bamako Convention uses a format and language similar to that of the Basel Convention, it is much stronger in prohibiting all imports of hazardous waste. Additionally, it does not make exceptions on certain hazardous wastes (like those for radioactive materials) made by the Basel Convention.

Article 9 (Illegal Traffic) of the Bamako Convention prohibits any trans-boundary movement of hazardous wastes under the following conditions:

- if carried out without notification, pursuant to the provisions of this Convention, to all States concerned; or
- if carried out without the consent, pursuant to the provisions of this Convention, of a State concerned; or
• if consent is obtained from States concerned through falsification, misrepresentation or fraud; or
• if it does not conform in a material way with the documents; or
• if it results in deliberate disposal of hazardous wastes in contravention of this Convention and of general principles of international law.

The Convention requires its signatories to introduce national legislation to criminalise and impose high punitive measures on all persons who have planned, carried out, or assisted in the illegal trans-boundary movement of hazardous wastes.

3.5.3 **IFC Performance Standards on Environmental and Social Sustainability (2012)**

In 2005 the IFC, which is the private sector arm of the World Bank Group, embarked on an extensive review of its environmental assessment procedures and PS. A revised and slightly more rigorous and more clearly defined PS as well as its associated Guidance Notes were published in January 1, 2012. These PS (Box 1) usually form the back-bone of Environmental, Social & Health Impact Assessments (ESHIA) and environmental management for large projects in developing countries and can be used to identify and manage risk in proposed developments.

**Box 1: IFC Performance Standards (January, 2012)**

<table>
<thead>
<tr>
<th>Performance Standard 1:</th>
<th>Assessment and Management of Environmental and Social Risks and Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Standard 2:</td>
<td>Labour and Working Conditions</td>
</tr>
<tr>
<td>Performance Standard 3:</td>
<td>Resource Efficiency and Pollution Prevention</td>
</tr>
<tr>
<td>Performance Standard 4:</td>
<td>Community Health, Safety, and Security</td>
</tr>
<tr>
<td>Performance Standard 5:</td>
<td>Land Acquisition and Involuntary Resettlement</td>
</tr>
<tr>
<td>Performance Standard 6:</td>
<td>Biodiversity Conservation and Sustainable Management of Living Natural Resource</td>
</tr>
<tr>
<td>Performance Standard 7:</td>
<td>Indigenous Peoples</td>
</tr>
<tr>
<td>Performance Standard 8:</td>
<td>Cultural Heritage</td>
</tr>
</tbody>
</table>

Of specific relevance to this report is Performance Standard 3 (PS3) which deals with resource efficiency and pollution prevention. The primary objectives of PS3 are to:

• Avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
• Promote more sustainable use of resources, including energy and water.
• Reduce project-related Greenhouse Gas emissions.

The primary requirement of PS3 is that technologies and practices that avoid or minimise detrimental impacts of pollution are applied throughout the lifecycle of the project.

In addition to the IFC PS, the General Environmental, Health and Safety Guidelines (2007) described below (section 3.5.3), and the Industry-Sector IFC EHS Guidelines for Mining (2007), which deal with pollution and human health issues associated with mining (section 3.5.4), are of equal relevance.

3.5.4 **IFC General Environmental, Health and Safety Guidelines (2007)**

The IFC General EHS Guidelines (2007) are technical reference documents with general and industry specific examples of Good International Industry Practice (GIIP) as defined in the IFC’s PS3 on Resource Efficiency and Pollution Prevention. The IFC uses the EHS Guidelines as a technical source of information during project appraisal activities as described in the IFC’s Environmental and Social Review Procedures (2006).
According to the General EHS Guidelines, facilities that generate and store wastes should practice the following:

- Establishing waste management priorities at the outset of activities based on an understanding of potential EHS risks and impacts and considering waste generation and its consequences;
- Establishing a waste management hierarchy that considers prevention, reduction, re-use, recovery, recycling, removal and finally disposal of wastes;
- Avoiding or minimizing the generation of waste materials, as far as practicable;
- Where waste generation cannot be avoided but has been minimized, recovering and reusing waste, and;
- Where waste cannot be recovered or reused, treating, destroying and disposing of it in an environmentally sound manner.

Section 1.3 of the IFC General EHS Guidelines (2007) provides specific recommendations related to the management of wastewater and includes indicative values for treated sanitary sewage discharges (Appendix A), while those for mining effluent are provided in IFC EHS Guidelines for Mining (2007) (Appendix B).

3.5.5 IFC EHS Sector-Specific Guidelines

Whilst the IFC PS, of which some parts relate to all phases of a project’s lifecycle - planning, design, construction, operation and decommissioning / closure – the IFC Industry Sector EHS Guidelines relate specifically to the construction and operational phases of specific projects. The purpose of these guidelines is to compliment the Performance Standards by providing more detailed guidance on the environmental and social impacts likely to be associated with specific industry sectors, as well as specific limits.

The Guidelines are therefore technical reference documents that recommend general industry-specific examples of GIIP, and they provide performance levels and measurable objectives for new and existing facilities, including specific targets by which GIIP may be achieved. These industry sector EHS guidelines are designed to be used together with the General EHS Guidelines (2007) document (described above), which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. The IFC Industry Sector EHS Guidelines of relevance to the proposed project are:

- IFC EHS Guidelines for Mining (2007); and
- IFC EHS Guidelines for Integrated Steel Manufacture (2007)

The second of these includes specific sections on typical solid waste and by-products as well as waste water from iron and steel manufacturing facilities.

3.5.6 Other useful reference sources

In addition to the abovementioned guidance documents, a number of other international guidelines provided useful information that was considered relevant to the project and included:

- AfDB Guidelines for Mining Projects (1995)
3.6 Waste Management Infrastructure in Mozambique

Mozambique has a modern and progressive waste management system regulation. However, despite a clear political objective, many people still do not have access to adequate and proper waste management and sanitation infrastructure (BTI 2012). Search on the internet reveals minimal progress being made in the development of waste infrastructure in Maputo, while there is a general lack of waste management infrastructure throughout the rest of the country. According to a draft report by the United Nations (www.un.org), urban solid waste is managed informally. Typically, the final destination of solid waste in Mozambique consists of simple open air rubbish dumps. In these places, waste is burnt, buried and compacted, causing certain environmental and health concerns.

According to the draft UN report (no date), informal recycling of solid waste does take place and is often located at the disposal sites. Furthermore, recycling is more prevalent in the larger cities, due to the quantities of waste available and the increased likelihood of finding a buyer for the material. Some of the recycled material, such as glass, plastic and metal, is sold locally but it is also transported to South Africa. In addition to this informal recycling, there is also evidence of the initiation of more formalised recycling operations in the larger cities of Maputo and Matola. An organization called Amor (the Mozambican Association of Recycling – see www.associacao-mocambicana-reciclagem.org) has been in operation since 2010 and focuses on using recycling initiatives for socio-economic upliftment. Such initiatives do, however, seem to be limited to the larger urban areas with no evidence of formalised recycling in rural areas.

Disposal of hazardous waste in Mozambique poses a challenge. According to the Basel Convention Country Fact sheet for Mozambique (2008), the Mavoco hazardous waste disposal facility near Maputo is currently the only licensed hazardous waste site in the country. This situation may change in the near future as new facilities for the disposal of industrial waste are developed elsewhere in the country to support growth of the industrial and mining sectors. In particular, there are reports that establish companies such as Enviroserve and Interwaste are expanding their waste management services into Mozambique. According to a 2012 online report (www.macuahub.com), development of a landfill for industrial waste is being considered for Moatize in Tete Province.
4 METHODOLOGY

4.1 Introduction

This assessment did not include a visit to the proposed project site. Instead, information regarding the process, expected waste volumes and properties of the wastes was obtained from client. In terms of rating of potential environmental waste impacts, the standard CES rating system was applied and the specific context of the proposed project was taken into consideration.

4.1.1 Waste characterisation methodology

Information regarding the process, expected waste volumes and properties of the wastes was obtained directly from the client. Additional information was obtained from relevant reference sources. A life cycle assessment approach with a limited spatial scope was used to identify all key waste streams associated with the proposed project. The assessment covered waste streams during the construction, operation and decommissioning phases of the mine and pig iron production facility. Transport of the final product has not been considered.

For the purposes of this report, waste streams generated during the operational phase have been defined as either process wastes or non-process wastes. The former may be defined as any liquid or solid wastes generated directly as a result of the core process described in section 2.3.2, while non-process wastes refer to those wastes that are generated from auxiliary operations or services as described in section 2.3.3. It is likely that the process and non-process waste streams will include both hazardous and general (non-hazardous) wastes. Waste streams originating during the construction and decommissioning phases are also covered in this report. The differentiation of the various waste streams is indicated in Figure 4.1. Although the methodology relies on consideration of each phase separately to identify waste streams, due to the high likelihood that similar non-process wastes will be produced throughout the different phases of the operation, this report discusses wastes by type rather than consideration of wastes by project phase.

Figure 4.1: Differentiation of waste streams associated with a generic industrial development

In terms of rating of potential environmental impacts, the standard CES rating system was applied. Details of this methodology are included in the main ESIAR and are not repeated here.
5 WASTE CLASSIFICATION AND QUANTIFICATION

5.1 Introduction

The purpose of this chapter is to describe the types, volumes and management options of wastes expected to be produced over the life of the project. This information will then inform the identification and assessment of waste-related impacts. Air emissions, including dust released to the atmosphere, have not been considered in this report as they will be considered in detail in a separate air quality specialist report.

5.2 Process wastes

“Process wastes” are defined as those produced as a direct result of the actual raw material extraction, beneficiation and processing. As such, these wastes are only produced during the operational phase of the project. The volumes of these waste streams are frequently significant and certain of these wastes may exhibit hazardous properties. Each of the process wastes associated with the proposed development is discussed below, and information on expected volumes and disposal options are summarised in Table 5.1.

5.2.1 Waste rock and tailings

Tailings from the dry processing scenario will be coarse and will be disposed of in the mine waste facilities as a dry product, forming integrated facilities for waste rock and tailings. Tailings from the dry-wet processing scenario will be both coarse (dry) and fine (wet). The coarse tailings will be disposed of in the integrated mine waste facilities, while the fine tailings will be thickened and disposed of in a dedicated TSF. The preferred location for the TSF is west of the processing plant area, however if restricted by other infrastructure, the TSF may be located to the south of the processing plant area. Based on a production scenario of 4Mt/annum for Tenge, the integrated mine waste facility will have a final height of 45 metres covering 54Ha with a capacity of 11.9Mm³. The Ruoni North waste dump has a maximum height of 55m; it covers 193Ha and has a capacity of 69.3Mm³.

5.2.2 Decant water from tailings

If the combined dry / wet separation option is selected then liquid waste will be generated as a consequence of the concentrate dewatering (thickener overflow) and also from the tailings dam that receives thickened tails (Figure 2.3). None of this water will be released to the environment but will instead be transferred to a process water dam for reuse in the plant.

5.2.3 Effluent from coal washing

The current project description does not include the washing of coal on site prior to use however, this may be considered in the future and as such, the management of coal-wash effluent should be considered. According to Ghose (2000), effluent from coal washing is characterised by high suspended solids content and chemical oxygen demand (COD). Suspended solids may exceed 20 000mg/L. This effluent will need to be treated, possibly with flocculants, prior to discharge or reuse. However, coal washwater discharged to the environment will need to meet the discharge limits specified in Appendix B.

5.2.4 Slag

At the time of preparing this report, no information was available on the amount of slag to be produced or the fate, whether re-use or disposal, of this material.

The project description indicates that titanium-rich (50% TiO₂) and vanadium slag (10% V₂O₅) will be produced as by-products of the pig-iron production process. According to a recent article released by the London Stock Exchange (www.londonstockexchange.com/exchange/news/market-
vanadium slag is of high value and will contribute to the overall financial success of the project. The fate of the titanium slag is yet to be confirmed but potential application for blast furnace slag includes use as an aggregate substitute in road construction or in the production of Portland cement (http://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/bfs1.cfm).

According to the IFC EHS Guidelines for Integrated Steel Production (IFC, 2007), where reuse of slag is not technically or financially viable, it should be disposed of in a landfill that has been designed to take into consideration the properties of the slag.

5.2.5 Pit decant water

Over the life of the mine, water will enter the pit either during rainfall events or from groundwater. In order to continue with operations, it will be necessary to periodically pump this water from the pit. Currently, no details are available on the likely quantities involved, the expected quality of this decant water or the mode of management. The primary concern is the potential for formation of Acid Rock Drainage (ARD), through oxidation of pyrite (FeS₂) and subsequent quality of the water discharged from the pit, in particular the potentially high salinity and metal concentration and low pH. The formation of ARD is a concern globally and there are numerous examples where generation of this pollutant persists for decades. The likelihood of formation of ARD at the Capitol site will need to be confirmed. However, any decant water discharged to the environment will need to meet the discharge limits specified in Appendix B. As such, this water may need to be treated prior to discharge.

5.2.6 Process dust

Although no details have been provided on management of dust from the beneficiation steps, it is likely that dust will be captured either using baghouses or electrostatic precipitators. The collected dust will then need to be disposed of. This is usually achieved by combining the dust with tailings prior to transfer to the TSF. The quantity of dust requiring disposal is unknown.

5.2.7 Refractories

Blast furnaces and ladles used in the manufacture of pig iron will be lined with refractories. These refractories generally have to be replaced periodically. No information is available on the quantity of refractory material requiring disposal or the likely disposal route. It is, however, assumed that they will be disposed of with the process tailings or at landfill site.

<table>
<thead>
<tr>
<th>Table 5.1: A summary of expected process wastes from the Tenge-Ruoni project</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process Waste</strong></td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Waste rock and tailings</td>
</tr>
<tr>
<td>Decant water from tailings</td>
</tr>
<tr>
<td>Effluent from coal washing</td>
</tr>
<tr>
<td>Slag</td>
</tr>
</tbody>
</table>
5.3 **Non-process wastes**

"Non-process wastes" are defined as those produced by auxiliary activities such as accommodation camp, workshops, administration blocks, laboratories, canteens, clinics etc. As such, these wastes are only produced during the operational phase of the project. The volumes of these waste streams are generally highly variable and difficult to predict and it is probable that certain of these wastes will exhibit hazardous properties. Each of the non-process wastes associated with the proposed development is discussed below, and information on expected volumes and disposal options are summarised in Table 5.3.

### 5.3.1 Vegetation

Preparation for the construction activities (construction phase) and actual pit mining (operational phase) will require clearing of existing vegetation from the site. The pit area is dominated by closed woodland vegetation with a relatively high biomass and although much has been cleared as a consequence of exploration work, vegetation cover is still estimated at approximately 60%.

Although the disposal route for cleared vegetation has not been specified, it has been assumed that the vegetation cleared from the land shall be disposed of by one or more different routes. These could include removal by local communities for construction, stockpiling and natural decomposition on-site wood chipping or burning. Usually, value added processes are preferred in the disposal of vegetation and the milling of felled trees in preference to chipping or mulching is encouraged. However, chipping and mulching is preferred to on-site burning. On-site burning is usually permitted where it can be satisfactorily demonstrated that the requirement to mill and/or chip and mulch cleared vegetation would be an unreasonable imposition on the development. The loss of vegetation will need to be considered when calculating the overall greenhouse gas emissions for the project.

### 5.3.2 General (non-hazardous) solid wastes

All phases of the proposed development will result in the generation of general (non-hazardous) solid waste. It will be produced by all of the auxiliary services such as administration areas, workshops, the camp, stores etc. This waste stream could therefore include vegetable / food waste, paper, cardboard, cloth, metal, plastic, rubber, glass and a variety of synthetic compounds. At this early stage it is not possible to accurately predict the exact nature and quantities of wastes produced during decommissioning although non-hazardous wastes will most likely include potentially significant quantities of rubble, piping and metal in addition to plastic, glass etc.

Unless a culture of separation of non-hazardous from hazardous wastes at source is entrenched, relatively insignificant quantities of hazardous wastes may be included in this waste stream, including batteries, empty containers for cleaning chemicals, fluorescent light tubes, pesticide aerosol cans, medical / clinic wastes etc. Types of non-process non-hazardous wastes that may be associated with this development are described in Table 5.2.

While it is possible to predict with some degree of certainty the types of waste that will be produced, it is extremely difficult to estimate the quantities of the different non-process general waste types. However, the volume of this waste type will be influenced to some degree by the number of individuals living on the site. According to the World Bank Technical Paper No. 426 (Rushbrook and Pugh, 1999), the estimated rate of generation of domestic waste in developing countries is approximately 0.5kg per person per day, at an estimated density of 151kg/m³. As such,
a construction workforce of 3000 individuals (maximum) could, without contributions from other sources during the construction, generate 1500kg of solid domestic waste \((or 10m^3)\) per day. The quantity of waste from this source is expected to be lower during the operation phase (approximately 250kg or 1.6m\(^3\) per day).

Non-hazardous wastes will be separated from hazardous wastes at source and all wastes will initially be stored on site in a dedicated area prior to safe disposal. Based on information provided and as required by Article 9, Decree 13/2006 (Regulation of Waste Management), where possible, wastes will be separated for recycling and non-recyclable wastes should be disposed of at a general landfill. Considering the remote nature of the project site, it will be necessary to consider construction of such a facility at the mine site. This option is considered to be the best practicable environmental option (BPEO) over the medium- to long-term and is the preferred alternative when compared against the disposal at an existing landfill site given the remote location of the mine site and apparent challenges associated with management of solid wastes in Mozambique. Further consideration of this option will need to take cognisance of the proximity and potential impacts to local surface and groundwater resources. Guidance on the design and location of an on-site landfill for general waste from the mine is provided in Appendix D.

### 5.3.3 Hazardous solid and liquid wastes

Due to the nature of the proposed operation, it is likely that all of the auxiliary services that produce general waste will also produce a range of hazardous liquid and solid wastes, although in relatively limited quantities. A definition of hazardous waste is provided in Section 3.2 of this report and they normally exhibit properties including toxicity, corrosivity or flammability. Types of non-process hazardous wastes that may be associated with this development are described in Table 5.2. Based on information provided by the client, there will not be any sources of radioactive waste generated by the operation. Key sources of hazardous wastes during the operational phase will be workshops, on-site laboratories and medical facilities.

As with non-hazardous wastes, it is not possible to accurately predict the exact nature and quantities of hazardous wastes produced during decommissioning although this may include tanks and pipes that have been used to store or transport hydrocarbons. The quantity and management options would need to be accurately assessed prior to decommissioning.

In terms of the management of hazardous waste streams it would be considered best practice to adopt a waste management hierarchy whereby the production of these wastes is prevented or minimised as far as possible. Where these wastes are produced they should be recycled wherever practical. In terms of the Precautionary Principle which underpins the NEMP (1995) (described in Section 3.4.3), all wastes should be considered hazardous unless proven otherwise. It is essential to separate hazardous and general wastes and correctly label all wastes. Unknown wastes must be regarded as hazardous and managed and disposed as such. This includes sludge from settling steps or waste water treatment plants that may contain toxic heavy metals.

The management of medical waste requires particular attention. The first aid station that will be located at the mine will most likely generate some medical waste that would need to be managed and disposed. Medical wastes typically associated with such a facility include small quantities materials described in Table 5.2. Much of the medical waste should be regarded as bio-hazardous and would therefore need to be disposed of by incineration, to render inactive, prior to its final disposal at the on-site landfill. Until such time as the on-site incinerator is operational, the medical wastes will be transferred to the Tete Provincial Hospital in Tete City for proper disposal. The storage of medical waste should only be at the temporary hazardous waste storage facility. Regardless of what option that is adopted, all medical waste should be managed in accordance with the management procedure described in Annex 3 of the International Committee of the Red Cross (ICRC) Medical Waste Management (2011) and the requirements of the Mozambican legislation. Where there is a difference between these two sources of guidance, the most stringent should be applied.
The ICRC guidance stipulates the preparation of a waste management plan that includes the following elements:

- Quantification of different medical waste types from different sources
- Describing current waste management practices including disposal routes and training
- Review of existing policies and national waste management strategies
- Development of a waste flow diagram (similar to a decision support tool)
- Development of an audit checklist

Annex 3.5 of the document provides specific guidance on the transportation of hazardous materials by road, including packaging and signage requirements.

Although the safe disposal of other types of hazardous wastes within the country is possible, the only available facility is the Mavoco landfill facility near Maputo, which is over 1 500 km away. There do, however, appear to be plans underway to develop additional sites for the disposal of industrial waste closer to the project site and according to Capitol Resources, a facility in Tete Province is expected to be operational by 2017. Annex IX of the Regulation of Waste Management (Decree No. 13/2006) provides the basic norms and procedure for the transportation of hazardous wastes. It should be noted that in addition to the significant costs associated with transport of hazardous wastes over such long distances, the potential environmental, health and safety impacts associated with transportation of this material must also be considered. The most practical alternative is to treat by incinerating and or dispose of the hazardous waste in a dedicated purpose-built cell in a new on-site landfill. The viability and acceptability of designing and constructing a dedicated cell for disposal of project-related hazardous wastes would need to be investigated, should this alternative be adopted. Alternatively, the transportation and export of hazardous wastes would need to comply with the requirements of the Bamako Conventions.

Irrespective of the disposal option, it will most likely be necessary to store at least small quantities of hazardous waste on site until the volumes are sufficient to warrant either off-site transportation or incineration. As such, it is advisable to construct a secure, bunded facility on the site for the temporary storage of hazardous wastes.

**Table 5.2: Typical non-process hazardous waste (solid and liquid) likely to be produced during the operational phase of a generic industrial development**

<table>
<thead>
<tr>
<th>Service / area</th>
<th>Typical hazardous wastes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaged sewage treatment plant</td>
<td>Sewage sludge.</td>
</tr>
<tr>
<td>First aid stations</td>
<td>Sharps (needles &amp; blades), bandages, expired medication, gloves, biological waste</td>
</tr>
<tr>
<td>Workshops / maintenance activities</td>
<td>Chemical containers, solvents, paints, hydrocarbon products including waste lubricating oil, oily rags and vehicle parts and machinery, batteries, hydrocarbon-contaminated absorbent material used to clean up spills</td>
</tr>
<tr>
<td>Administration</td>
<td>Electronic equipment, fluorescent tubing, solvent-based cleaning agents, pesticide cans</td>
</tr>
<tr>
<td>Canteen / kitchen</td>
<td>Used cooking oil</td>
</tr>
<tr>
<td>Vehicle wash bay and bunded fuel and waste storage areas</td>
<td>Wastewater containing hydrocarbons, fertilizer and pesticides</td>
</tr>
<tr>
<td>Effluent treatment plants / settling steps</td>
<td>Sludge containing heavy metals</td>
</tr>
</tbody>
</table>
5.3.4 Sewage and wash water

Domestic sewage is characterised by a high concentration of nutrients, organic matter and a variety of pathogens. As such, it must be properly treated prior to discharge to avoid negative impacts to human and environmental health. The presence of hazardous chemical contaminants is unlikely when the domestic sewage is not combined with industrial effluents, machine wash water or with effluent from the laboratory, which should be prohibited.

The construction workforce of up to 3000 individuals (at peak construction) will generate sewage and wash water that will need to be managed. Based on a low estimate of 0.025m$^3$ per person per day the total volume of domestic effluent requiring disposal during this phase will be at least 75m$^3$ per day. However, if a large proportion of the construction team are living on site and / or have access to bathing facilities then the volume of effluent requiring disposal could be closer to 0.2m$^3$ per person per day or a collective total volume of 600m$^3$/day. After completion of the construction activities, this will be reduced to approximately 100m$^3$/day.

Sewage and other effluent from ablution facilities will most likely be disposed of using septic tanks, although as the construction phase nears completion it may be an option to direct the sewage from the accommodation camp to a packaged sewage treatment plant. If septic tanks are to be used then careful consideration must be given to the relatively shallow water table in parts of the project area as establishment of septic tanks in areas with a shallow water table is not advisable.

If a package sewage treatment plant is constructed, treated effluent could then be discharged directly to the environment or sent to the process water dam from where it will be pumped to the process water tank to be used as recycled water for mineral processing. If the treated sanitary effluent water is discharged onto the environment, it must meet national discharge standards and, preferably, the most stringent limits identified in Appendix A of this report. There are a number of different package plant options on the market, each with their own advantages and disadvantages. Based on experience from other remote sites, it is recommended that the preferred options should incorporate the following characteristics:

- Proven ability to consistently produce treated effluent that meets the required discharge limits in a remote context with limited supervision is essential;
- No requirement for a fulltime skilled operator
- Minimal input of chemical agents
- Minimal monitoring and chemical analysis required for correct operation
- Minimal and / or infrequent management of sludge
- Rapid and reliable on-site technical assistance and availability of spare parts

Occasionally, sludge from the septic tanks and the sewage treatment package plant may have to be removed and this material, which should be regarded as hazardous due to the potential pathogen content, must be disposed of in accordance with the EHS Guidelines for Water and Sanitation (2007). Within the urban context the sewage sludge could be transferred to a municipal treatment plant for final treatment to a permissible quality for disposal. However, in the current context, this is not practical. As such, the sludge would need to be stabilized by drying in purpose-build beds or composting. The latter requires mixing the sludge with additional sources of carbon such as sawdust, straw or wood chips in the presence of oxygen to enable the indigenous bacteria to digest both the sludge and the added carbon source. The stabilized sludge can then be dried and either disposed at the proposed landfill or alternatively, applied as a soil conditioner during rehabilitation of the mine, provided that levels of toxic constituents is sufficiently low. If soil application is adopted, soil contamination should be avoided and the soil standard prescribed by the AfDB (Appendix C) should be adhered to.
The total quantity of effluent requiring disposal during the construction phase could be increased further by washing of equipment such as machinery and vehicles although the exact quantities produced by these activities cannot be determined. Wash water from vehicles frequently contains at least small quantities of hydrocarbons (oil, grease etc.) and, as such the washing of vehicles and machinery should be conducted only at permitted and well selected designated wash bay where wash water is collected and routed through a grease trap/oil-water separator prior to discharge.

5.3.5 Storm water other runoff

It is important to consider the potential environmental impacts associated with storm water and other run-off. This will include run-off from the stockpiles, waste rock dump and mine pit. The primary threat posed by storm water is that as it has the ability to pick up contaminants, including hydrocarbons, heavy metals, pesticides and nutrients as it moves across a project area. If not managed correctly, these contaminants may then be transported, via the storm water, into areas where they could pose a threat to human and environmental health.

The exact quantity of contaminated water requiring careful management and treatment prior to release from the site is likely to be highly variable and largely dependent on seasonal rainfall. Storm and machine wash water should be kept separate from the sewage. This would need to be addressed in the design of the storm water system for the site which should take into consideration the use of sealed manhole covers. Prior to discharge, storm water must meet the most stringent of national or IFC limits for effluent. In this case, the IFC discharge limits for mining operations and steel works are applicable (Appendix B).

Table 5.3: Summary of non-process solid and liquid waste streams associated with the Tenge-Ruoni project

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Estimated Quantity</th>
<th>Management &amp; Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleared vegetation</td>
<td>Variable but could be significant during establishment of the pit.</td>
<td>Ideally, local communities should be provided an opportunity to collect cleared vegetation for their own use. Remaining vegetation should be chipped or allowed to decompose in situ. Burning is the least favoured disposal option.</td>
</tr>
<tr>
<td>General (non-hazardous) solid waste</td>
<td>Variable</td>
<td>Separated at source from hazardous wastes. Recycle where possible and dispose of remaining waste at a new landfill at the project site. This facility will require a permit from MICOA.</td>
</tr>
<tr>
<td>Organic food waste</td>
<td>Variable</td>
<td>Waste vegetable matter produced during the preparation of food can be composted on site or disposed of at the landfill. Meat waste is not suitable for composting and will need to be buried at the landfill and covered immediately to minimise attraction of vermin.</td>
</tr>
<tr>
<td>Hazardous solid &amp; liquid waste</td>
<td>Variable but limited</td>
<td>Separated at source from general wastes. Stored on site at a temporary hazardous waste storage facility with secondary containment until exported for safe disposal. Alternatively, the hazardous waste is incinerated and or encapsulated before disposal at the on-site landfill site that has been designed to accept and effectively contain waste of this type.</td>
</tr>
<tr>
<td>Sewage / wash water</td>
<td>Up to 600m$^3$/day during construction and ~100m$^3$/day during operation.</td>
<td>Sewage generated during the construction and operational phases will be treated using a number of septic tanks. A package sewage treatment plant may be installed to treat sewage effluent from the accommodation camp during operation. All effluent will meet the discharge limits specified in Appendix A.</td>
</tr>
<tr>
<td>Medical waste</td>
<td>Variable but limited</td>
<td>Due to the remote location, all medical waste will be incinerated on-site and managed in accordance with the ICRC Medical Waste management requirement (2011). Until such time as the on-site incinerator is</td>
</tr>
</tbody>
</table>
### Waste Type

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Estimated Quantity</th>
<th>Management &amp; Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm water</td>
<td>Variable and expected to be high, especially during the raining season.</td>
<td>The storm water will be managed according to procedures that would be described in the Storm Water Management Plan. All storm water will meet the discharge limits specified in Appendix B prior to discharge.</td>
</tr>
<tr>
<td>Vehicle wash water</td>
<td>Variable but potentially high</td>
<td>All water from vehicle wash bays will pass through an oil-water separator prior to discharge at the process water dam.</td>
</tr>
<tr>
<td>Laboratory waste</td>
<td>Variable but limited</td>
<td>Laboratory wastes effluent will be separated from the sewage lines. Temporary storage of these wastes will be in a secure facility with secondary containment. As far as possible, these wastes will then be returned to the supplier or, if not possible, then disposed of with other hazardous waste. All laboratory wastes must be clearly labelled.</td>
</tr>
</tbody>
</table>
6 ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS

6.1 Introduction

This chapter deals with waste related impacts that will potentially be associated with the proposed Tenge-Ruoni iron ore project. These include all process and non-process related waste streams, including waste generated from all ancillary facilities. It should be noted that waste-related impacts to air and aquatic ecosystems have already been assessed in other specialist studies and so will not be repeated here. Similarly, the risks that the project poses to human health will also be covered by a separate Health Impact Assessment. The focus of this chapter will therefore be to identify possible waste-related impacts to aid assessment by other specialist teams, and to describe best practice with respect to management of waste streams. Information regarding the quantity of process as well as certain non-process wastes and their management was not available at the time of preparing this report and, as such, the impact assessment should be regarded as preliminary.

6.2 Impacts associated with process wastes

6.2.1 Issue 1: Disposal of waste rock and tailings (Operational phase)

Tailings and waste rock are expected to be generated from the iron ore mine throughout the life of the mine.

Impact 1.1: Health and safety of employees and local communities

Cause and comment

The management of all waste rock dumps and tailings storage facilities will conform to the requirements of the IFC’s EHS Guidelines for Mining (IFC, 2007). The integrated facility (for waste rock and coarse tails) and the TSF (for finer tails) will be designed by an independent recognised global expert in tailings dam design and will be managed according to international best practice.

Although the project area is only sparsely populated, the communities of Tenge-Makodwe and Nhambia are within the footprint of the project site. In the highly unlikely event of a TSF failure, unstable tailings material could pose a risk to members of nearby communities. In addition, there is also a chance of small scale instability events on the slopes of the rock dumps which may result in injury to employees working at the dumps but these risks would normally be managed along with other routine occupational health and safety risks.

Significance statement

A long term impact may occur within the study area and due to the potential for harm to individuals, including possible fatalities the severity of the impact is regarded as high. Without mitigation, significance will be HIGH and with mitigation, this could be reduced to LOW significance.

Mitigation measures

- The management of waste rock and tailings will conform to the requirements of the IFC’s EHS Guidelines for Mining (IFC, 2007);
- Mitigation measures could include limiting the size of the tailings and waste rock stockpiles by trucking to the waste rock dump as soon as possible and also careful selection of sites for stockpiling so as to minimise negative impacts to vegetation and water resource. In addition, seepage water should be channelled to a central collection point to avoid water resource contamination.
- As far as practical, the waste rock dump must be sited in a location such that in the event of failure, pollution of soil and water as well as physical risk to communities is minimised;
The integrity of the waste rock dump and tailings facility must be inspected regularly by suitably qualified personnel throughout the life of the mine;

Access to the TSF and waste rock dump should be restricted as far as practical and all local communities should be informed of the potential risks associated with these facilities through site notices and community meetings.

Relocation of the communities away from the waste rock dump.

### Impact 1.1: Health and safety of employees and local communities

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Temporal Scale: Long Term; Spatial Scale: Localized; Severity of Impact: Severe</td>
<td>May Occur</td>
<td>HIGH</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Temporal Scale: Long Term; Spatial Scale: Localized; Severity of Impact: Slight</td>
<td>May Occur</td>
<td>LOW</td>
</tr>
</tbody>
</table>

#### 6.2.2 Issue 2: Spillage of Run of Mine while Trucking (Operational phase)

**Impact 2.1: Disruption of ecological function**

**Cause and comments**

The transportation of extracted ore by trucking to the processing facility is anticipated to result in the some spillage of the ore materials on land. The ore material contains heavy metals that would be dispersed during transportation. Over time, this would accumulate resulting in the heavy metal contamination of soil. Spilled material could also result in increased turbidity of water bodies and smother plants.

**Significance statement**

Heavy metals have the tendency to accumulate within living organisms and can interfere with normal physiological processes leading to disruption of ecosystems. The disruption of ecosystems by heavy metals was determined to be Localized. Without mitigation the significance was considered MODERATE and with mitigation it was considered to be LOW.

**Mitigation measures**

- The trucks should not be overloaded with ROM and should be covered during transportation to prevent spillage;
- Speed limits should be set to prevent the spillage of ROM during trucking.
- In the event of significant spillages, these should be cleared up as soon as possible; and
- The environmental monitoring programme for the facility should be designed in such a way so as to detect impacts of spilled ore on terrestrial and aquatic ecosystems.

### Impact 2.1: Disruption of ecological function

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Temporal Scale: Long Term; Spatial Scale: Localized; Severity of Impact: Moderate</td>
<td>May Occur</td>
<td>MODERATE</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Temporal Scale: Long Term; Spatial Scale: Localized; Severity of Impact: Slight</td>
<td>May Occur</td>
<td>LOW</td>
</tr>
</tbody>
</table>
6.2.3 Issue 3: Storage of process effluent in the process water pond (Operational phase)

The Process Water Pond will serve as the collection point for the decant water from the tails and overflows from the tailing thickeners and concentrate thickeners. This effluent water will be diluted with water make-up from the environment and re-circulated to the process plant. It is anticipated that the re-circulated water in the Process Water Pond will contain at least low concentrations of heavy metals and, potentially, other contaminants such as residual flocculant. Over time, the re-circulation and evaporation may result in an increase in the concentration of the abovementioned compounds. The presence of a large pond containing process water containing potentially harmful substances could pose a threat to environmental contamination, particularly if the pond was to overflow after a period of heavy rainfall.

Impact 3.1: Pollution of soil and water resources

Cause and comment

In the event that the pond overflows or is otherwise compromised, the accidental release of stored process water and associated sediment, could lead to pollution of water resources and soil and an increase in the turbidity of nearby water bodies. The potential consequences of increased turbidity include reduced light penetration and growth of aquatic plants. This could have subsequent, long-term negative impacts on local ecosystems and human health.

Significance Statement

The impact of the pond water released into the ecosystem without mitigation was considered to be moderately severe with a MODERATE significance and with mitigation it was considered to be LOW with a slight severity. The following mitigation measures must be implemented to minimise this risk.

Impact 3.2: Risk to Health and Safety of Employees

Cause and comment

Water from the TSF and thickeners will be captured in a pond prior to blending with the input process water to the plant. The presence of a large pond containing process water which contains potentially harmful substances will pose a threat to the health and safety of employees. Access to the pond by individuals who are not able to swim may result in drowning.

Significance Statement

It is possible that without mitigation, an employee could fall into the TSF/pond and drown. As such, the impact to human health and safety without mitigation was considered to be very severe with a HIGH significance. The likelihood of the impact occurring could be reduced through implementation of mitigation measures. With mitigation, the overall significance of the impact is expected to be MODERATE.

Mitigation measures

- The TSF and process water storage pond will be fenced off and the gate locked at all times to limit unauthorised access;
- Flotation devices will be readily available around the facility;
- The Health & Safety induction training should incorporate these risks;
- The integrity of the TSF must be inspected regularly by an independent and suitably qualified and experienced engineer;
- The operation of the facility must ensure sufficient freeboard to ensure that the pond does not overflow;
- The quality of the stored process water should be monitored so that in the event of accidental discharge, the contaminants released into the environment are known.
- Warning notices should be placed around such facilities.

### Impact 3.1: Pollution of soil and water resources

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Medium Term</td>
<td>Moderately Severe</td>
<td>Probable</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long Term</td>
<td>Slight Severity</td>
<td>Probable</td>
</tr>
</tbody>
</table>

### Impact 3.2: Risk to health and safety of employees

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Medium Term</td>
<td>Very Severe</td>
<td>Probable</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Medium Term</td>
<td>Very Severe</td>
<td>May Occur</td>
</tr>
</tbody>
</table>

### 6.2.4 Issue 4: Management and disposal of slag (by-product) (Operational phase)

#### Impact 4.1: Contamination of land and water

**Cause and comments**

The slag is intended to be sold as by-product after characterisation and quality control measures have been developed and implemented. In the interim, the slag will be sent to the slag dump for disposal. Although limited information is available on the environmental impacts of pig iron slag, the greatest concern relates to leaching of compounds, including sulphur and heavy metals from the slag into water resources. The risks to water resources will, however, depend on the chemical composition of the slag and the pH of the surrounding environment.

**Significance statement**

The impact of the slag leachate released into the ecosystem without mitigation was considered to be moderately severe with a MODERATE significance and with mitigation it was considered to be LOW with a slight severity. The following mitigation measures must be implemented to minimise this risk.

**Mitigation measures**

- The slag should be disposed of in a landfill designed with consideration of the slag characteristics and prevent the seepage of leachate. Local geological conditions should be considered when locating slag dump sites;
- Prior to designing facilities for temporary storage or permanent disposal of the slag, it will be necessary to establish the likely chemical composition of leachate from the slag using the appropriate leach tests. If these tests indicate potential for environmental harm associated with release of leachate then protective measures will need to be incorporated into the design of the storage or disposal facilities. These could include incorporation of impermeable liners.

### Impact 4.1: Contamination of land and water

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Long Term</td>
<td>Moderate</td>
<td>May Occur</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long Term</td>
<td>Slight</td>
<td>Unlikely</td>
</tr>
</tbody>
</table>
6.3 Impacts associated with non-process wastes

In addition to the waste streams originating directly from the process, there are likely to be a number of other general and hazardous waste streams associated with the project that will require management. These waste streams will be generated during the construction, operation and decommissioning phases. While recycle of certain types of non-process wastes should be possible, temporary storage may still be required. Where a single issue is potentially associated with more than one impact and where significance ratings and mitigation measures are similar, these have been discussed together.

6.3.1 Issue 5: Management of non-process general and hazardous wastes (Construction, Operation and Decommissioning)

Impact 5.1: Pollution of land and water

Cause and comment

Inappropriate storage of wastes, particularly those exhibiting harmful properties (i.e. hazardous wastes), can result in the contamination of land and water resources. As a result of rainfall events, leachate may be formed as water percolates through the solid waste, and this leachate may contain nutrients and a variety of toxic compounds, including metals. As such, it could result in the contamination of water and land. In extreme cases, release of large quantities of nutrients to a water body can result in eutrophication. The presence of certain toxic compounds in water as a result of pollution by wastes may have significant long-term negative impacts on the aquatic ecosystems and render the water unsuitable for certain applications including human consumption.

Mitigation measures (General wastes)

- All wastes must be managed according to the requirements of Mozambican legislation and, preferably, the requirements of the IFC General EHS Guidelines (2007);
- As far as practicable, the philosophy of the waste management hierarchy should be applied to the management of all waste streams;
- All general wastes that cannot be reused or recycled should be stored temporarily in a dedicated area and then transported regularly to the proposed landfill for disposal;
- Due to the lack of formal waste disposal facilities within the vicinity of the project, it is recommended that a landfill site be established and operated on site by the proponent. The proposed general landfill site must be sited, designed and operated to international standards in order to isolate the wastes and prevent environmental contamination, particularly groundwater contamination (EHS Guidelines for Waste Management Facilities 2007 and EPA 2000) and must be licenced by the developer early in the construction phase. Until such time as this facility is fully operational, all general waste produced during the construction phase must be stored on site in a secure access control area, in a legally-compliant manner that minimises environmental impacts;
- Due to the shallow water groundwater in certain areas of the concession, the landfill site must be located and designed in such a way as to minimise the risk of contamination of this water resource;
- It will be essential to implement a ground water monitoring system in the vicinity of the constructed landfill site in order to detect any changes to the quality of sub-surface water;
- All bins for temporary storage of waste that are located outdoors should be covered to prevent ingress of water and access by animals;
- A comprehensive Integrated Waste Management Plan should be developed for the site and it should include Key Performance Indicators (KPIs) against which the management of wastes can be audited;
- All employees, contractors and visitors to the site must be informed of correct waste management procedures, including separation of general and hazardous waste at source;
- Waste storage and disposal areas must be located at least 100m from surface water resources or important drainage lines.
Mitigation measures (Hazardous wastes)

- The Integrated Waste Management Plan for the facility must cover the management of hazardous wastes;
- Prior to safe disposal, all hazardous wastes must be temporarily stored at the temporary hazardous waste storage facility. This facility should be designed to include secondary containment lined and covered to protect the contents from weather (sunlight and rain). If wastes are corrosive, the base of the storage facility should be lined with an acid-resistant coating;
- Where possible, empty containers for hazardous chemicals will be returned to suppliers. Where empty containers for hazardous chemicals (hydrocarbons, pesticides, laboratory chemicals, degreasing agents etc.) cannot be returned to the suppliers, they must be triple-rinsed, punctured and stored in a secure area until such time as they can be disposed of safely. Rinse water may not be discharged directly to the environment;
- Empty pesticide containers should be disposed of according to the Food and Agricultural Organisation’s Guidelines on Management Options for Empty Pesticide Containers (Food and Agriculture Organisation (FAO) 2008);
- As per the FAO (2008) guidelines, burning of empty pesticide containers should be strongly discouraged. Specific guidance on the management of empty pesticide containers is provided by the FAO (2008);
- A hydrocarbon management Operating Procedure should be designed and implemented. Copies of this document should be made available at designated facilities where hydrocarbons are used or stored. The purpose of this procedure is to provide for the proper storage and handling of hydrocarbons, including waste hydrocarbons, on site and hence prevent any form of contamination;
- It is recommended that soil contaminated with hydrocarbon should be immediately removed and disposed of at a soil bioremediation facility on site or else disposed of as hazardous waste;
- MSDS for all chemicals must be readily available on site and the precautions stipulated in these must be adhered to at all times. All staff must be trained on the correct management of bunded facilities, including the discharge of collected liquids;
- Spill kits must be readily available at strategic points throughout the site and staff must be trained on the correct use of these kits;
- No hazardous wastes should be disposed of into drains as this may impact negatively on the performance of the septic tanks;
- Medical waste must be managed according to the management procedure described in Annex 3 of the ICRC Medical Waste Management (2011) and the requirements of the Mozambican legislation. It is proposed that this will be transported to the Tete Provincial Hospital for safe disposal until such time as the on-site incinerator has been commissioned. Incinerated material can then be disposed of at the proposed on-site landfill.

Significance statement
Impacts associated with the management of general (non-hazardous) solid waste may occur and the impacts are potentially long-term. The extent of the impacts (excluding potential impacts to water resources which are assumed to be covered in the Surface Water specialist report) are likely to be limited to the study area. Without mitigation the impacts will definitely occur and should probably be regarded as moderately severe. With the recommended mitigation the severity could be reduced to slight. The overall significance of the impact without mitigation would be MODERATE but with mitigation would be LOW.

Based on the most likely nature of non-process hazardous wastes, impacts may occur and, due to the potential for certain hazardous substances to accumulate in the environment, are potentially permanent. Due to potential transport of these substances into water, their impact may be of significance to the district. Without mitigation the impacts will definitely occur and would probably be regarded as very severe and of VERY HIGH significance. However, with mitigation the severity could be reduced to moderate and the overall significance of the impact would be MODERATE.
Impact 5.1: Pollution of land and water

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal Scale</td>
<td>Spatial Scale</td>
<td>Severity of Impact</td>
<td></td>
</tr>
<tr>
<td>General (Non-hazardous) wastes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long term</td>
<td>Study area</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long term</td>
<td>Study area</td>
<td>Slight</td>
</tr>
<tr>
<td>Hazardous wastes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Very Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Impact 5.2: Nuisance impact (Production of odours, visual impact and attraction of pest and vermin)

**Cause and comment**

The uncontrolled storage of solid waste, in particular food waste, can attract vermin and pests including rodents, birds and flies. These vermin / pests may pose a nuisance to adjacent communities of Tenge-Makodwe and Nhamidima and may act as vectors for disease. The uncontrolled storage of solid waste can result in the release of unpleasant odours which may be regarded as a nuisance to adjacent land-users, particularly that down-wind of the material. Odorous compounds are also released from relatively well-managed solid waste disposal facilities. The presence of large quantities of litter around the facility or at the proposed landfill may constitute a visual impact to employees and local communities.

**Mitigation measures**

Refer to mitigation measures for Impact 4.1 (above).

**Significance statement**

Nuisance impacts associated with the management of solid waste will probably occur and the impacts are potentially long-term but limited to the study area. Without mitigation the impacts should probably be regarded as moderately severe but with mitigation the severity could be reduced to slight. The overall significance of the impact without mitigation would be MODERATE but with mitigation would be LOW.

Impact 5.2: Nuisance impact (Production of odours, visual impact and attraction of pest and vermin)

<table>
<thead>
<tr>
<th>Impact</th>
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<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal Scale</td>
<td>Spatial Scale</td>
<td>Severity of Impact</td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long-term</td>
<td>District</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long-term</td>
<td>District</td>
<td>Slight</td>
</tr>
</tbody>
</table>

6.3.2 Issue 6: Disposal of domestic wastewater and sewage sludge (Construction, Operation and Decommissioning)

Impact 6.1: Pollution of soil and water

**Cause and comment**

Domestic sewage is characterised by a high concentration of nutrients, high organic matter and a variety of pathogens. As such, it must be properly treated prior to discharge to the environment to avoid negative impacts to human health and the environment. If untreated sewage is discharged to the environment, the high nutrient concentration could lead to eutrophication of surface water.
resources and subsequent disruption of ecological function within the aquatic environment. The sewage sludge from sanitary treatment facilities would have to be removed periodically. The sludge would have to be treated and disposed of as described in section 5.3.4. Sewage sludge also contains high concentrations of nutrients and may have a similar impact on water resources if not stored and disposed of in a manner that minimises the likelihood of migration of contaminants from the sludge to water resources.

**Mitigation measures**
- All domestic wash water and sewage from all sites must be diverted to the septic tanks or packaged sewage treatment plants for treatment and discharge from these facilities must meet the discharge standards as indicated in Appendix A prior to release into the process water pond. Sewage sludge from these facilities should be manage as described in the EHS Guidelines for Water and Sanitation (2007), that is stabilize by drying in purpose-build beds or composting. The stabilized sludge can then be dried and either disposed at the proposed landfill or alternatively, applied as a soil conditioner during rehabilitation of the mine, provided that levels of toxic constituents is sufficiently low. If soil application is adopted, soil contamination should be avoided and the soil standard prescribed by the AfDB (Appendix C) should be adhered to.
- The pre-treatment of oil and grease containing effluents from canteens by the use of a grease trap prior to discharge into sewage treatment facilities;
- Chemical toilets should not be used during the construction period unless the contents can be disposed of in a manner that does not pose a threat to the environment. Instead, alternatives such as VIPs, composting toilets or similar should be considered as preferred alternatives. However, the design and location of these will need to take into consideration the risk to groundwater resources;
- If VIPs are used, they must be lined, maintained and sited in a way that minimises the risk of contamination of surface and sub-surface water resources;
- All sewage treatment facilities should be well maintained. To this end, at least one employee on site must be trained to maintain the system(s);
- The performance of the sewage treatment systems must be monitored regularly. Where a system is found to performing poorly, the cause of the poor performance must be investigated timely and remediation measures put in place to restore performance;
- In the event that sludge must be removed from the system(s), it must be disposed in a manner that minimises potential risk to human health and the environment and should comply with the National legislation;
- The environmental monitoring programme for the facility must incorporate monitoring points that are able to detect a negative impact on the environment associated with the discharge of treated sewage.

**Significance statement**
Environmental impacts associated with the disposal of sewage will definitely occur. As the proposed project will be operational for approximately ~36 years, impacts associated with the release of untreated effluent and poor sludge management are potentially long-term and may affect the study area. Without mitigation the impacts on soil and water would probably be moderately severe and of MODERATE significance. However, with implementation of the recommended mitigation measures the severity of the impacts would be slight and of LOW significance.

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Temporal Scale</th>
<th>Spatial Scale</th>
<th>Severity of Impact</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td></td>
<td>Long-term</td>
<td>Study area</td>
<td>Moderately Severe</td>
<td>Probable</td>
<td>MODERATE</td>
</tr>
<tr>
<td>With Mitigation</td>
<td></td>
<td>Long-term</td>
<td>Study area</td>
<td>Slight</td>
<td>Probable</td>
<td>LOW</td>
</tr>
</tbody>
</table>
Impact 6.2: Health impacts to employees and communities

Cause and comment
Sewage and sewage sludge is normally characterised by high concentrations of pathogenic microorganisms (viruses and bacteria) and helminths. Exposure to untreated effluent, either directly or through contaminated water resources, can result in the spread of numerous diseases including cholera.

Mitigation measures
Refer to mitigation measures for Impact 6.1 above. In addition, the following mitigation measures are applicable:
- Any employees tasked with management of sewage and sanitation systems should be vaccinated against key diseases, such as hepatitis B, associated with these waste streams.

Significance statement
Pathogenic microorganisms are commonly found in untreated sewage and release of these organisms to water bodies used for irrigation, drinking, recreation or fishing can result in the spread of disease such as cholera. The health impacts associated with the release of untreated sewage effluent and poor sludge management are potentially long-term and may affect the district. Without mitigation the associated health impacts would probably be severe and of HIGH significance. However, with implementation of the recommended mitigation measures the impacts would be of slight severity and of LOW significance.

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Long-term</td>
<td>District</td>
<td>Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long-term</td>
<td>District</td>
<td>Slight</td>
</tr>
</tbody>
</table>

Impact 6.3: Nuisance impacts (odour and flies)

Cause and comment
Raw sewage, sewage sludge and sewage treatment facilities are frequently associated with the release of unpleasant odours and may attract large numbers of insect pests such as flies. The persistent odours and presence of insect pests would most likely be regarded as a nuisance to employees and local community members. If sewage is managed correctly, the level of these nuisance factors can normally be reduced significantly.

Mitigation measures
Refer to mitigation measures for Impact 6.1 above.

Significance statement
The management of sewage will definitely be associated with odours and insect pests and, due to the influence of wind, the impact on any one receptor would probably be short-term. The treatment plant will, however be relatively small and so the impact is likely to be confined to the study area. There are also currently no communities in the immediately vicinity of the mine. Without mitigation the impacts would probably be Moderately Severe and of MODERATE significance. However, with implementation of the recommended mitigation measures the impacts would probably be of slight severity and of LOW significance.
6.3.3 Issue 7: Disposal of run-off / storm water (Construction, Operation and Decommissioning)

Impact 7.1: Pollution of land and water

**Cause and comment**
Run-off water is likely to be generated on site as a result of the high rainfall, washing of machinery (including vehicles) and, possibly, dust suppression activities. As this water migrates across the site it has the potential to pick up various pollutants such as hydrocarbons and small solid particles. Furthermore, the run-off from machine washing activities is also likely to contain hydrocarbons. If this water is discharged without treatment, chemicals (hydrocarbons, pesticides etc.) and sediment could be transported into surface and sub-surface water bodies, resulting in ecological disruption.

**Mitigation measures**
- The management of all run-off must comply, as a minimum, with the requirements of Mozambican legislation but preferably with the requirements of the IFC's General EHS Guidelines (2007);
- A Storm Water Management Plan must be developed for the mine and it should incorporate measures to divert clean storm water away from stockpiles, waste storage and disposal areas and other operation areas;
- Mitigation measures should be aimed at reducing contact between storm water and hazardous chemicals. This needs to be considered during the planning of the storm water drainage system for the mine facilities;
- In terms of minimising discharge of pollutants and run-off quantity requiring treatment, all storm water run-off must be properly segregating and clean water run-off diverted to prevent it mixing with water containing a high solids content, to minimize the volume of water to be treated prior to release;
- All run-off from machine wash areas must pass through an oil trap and should be treated as hazardous due to the presence of hydrocarbon. All other run-off water must pass through a sediment trap to remove the majority of suspended solids prior to discharge to the environment. All settled material must be disposed of at the landfill; and
- The quality of all liquid waste streams discharged from the site, including storm water, must be monitored regularly to ensure compliance with the requirements of relevant legislation and standards.

**Significance statement**
Impacts associated with the disposal of run-off may occur and the impacts are possibly Long-term and, considering the relatively dry climate, impacts may be of significance to the study area. Without mitigation the impacts should be regarded as moderately severe but with mitigation the severity could be reduced to slight. The overall significance of the impact without mitigation would be MODERATE but with mitigation would be LOW.
### Impact 7.1: Pollution of land and water

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Long-term</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long-term</td>
</tr>
</tbody>
</table>

### 6.4 Cumulative impacts (Construction and operation phases)

#### 6.4.1 Issue 8: Regional waste profiles and community awareness

In addition to consideration of direct impacts associated with the production of waste streams by the proposed development, it is also necessary to consider the cumulative impacts which may manifest as a consequence of multiple large-scale commercial developments within the region. With respect to waste management, key considerations are the change in the profile of waste streams produced by local communities and awareness of local community members about the management wastes. Each of these is discussed in more detail below.

#### Impact 8.1: Local knowledge of waste management practices

**Cause and comment**

Based on available information, there appears to be a lack of well-designed and operated waste management infrastructure, including disposal facilities, and recycling initiatives in the Tete Province. The knowledge amongst local community members of the need for and best practice regarding management of waste streams is expected to be limited. While a limited knowledge of waste management may not pose a significant risk while communities subsist largely off agriculture and use of natural resources, the potential risks to environmental and human health are expected to increase as communities become more affluent and densely populated and the waste profile change to resemble those more commonly associated with urban societies. In particular, the quantity of waste may increase and waste streams may start to include a greater proportion of non-biodegradable materials and even small quantities of hazardous wastes.

It is expected that a significant proportion of the employees at the Tenge-Ruori iron mine will come from local communities. In addition, other individuals from the same villages may be employed at other large-scale developments proposed for the area. Through their employment at such operations, these local community members will be trained on a range of environmental issues, including the correct management of waste. This knowledge may then be transferred to other members of the local communities, thus resulting in a general increased awareness of the importance of waste management, and potential opportunities for recycling, within the local communities.

**Mitigation measures**

- Train all employees on the importance of proper management of waste streams and sanitation;
- Consider options to facilitate improved management of solid waste in local communities. This may include training local communities on composting techniques. This may be incorporated into an urbanisation plan for the area.
- Consider involving local communities in waste recycling initiatives if these are considered practical within the context of the project.

**Significance statement**

The development of a knowledge and appreciation of the need for sound waste management amongst employees, and subsequent informal dissemination of this knowledge into local communities may ultimately, together with the provision of waste management infrastructure such as formal temporary storage areas or a landfill (perhaps through an urbanisation plan), result in an
improved management of waste streams within the local communities. As one of the positive impacts would be an enhanced local knowledge, the impact may be considered permanent. Without mitigation the impact would possibly be considered to be slightly beneficial and of LOW significance. However, with mitigation, the impact could be considered beneficial and of MODERATE positive significance.

**Impact 8.2: Change to waste profiles in the local communities**

**Cause and comment**
The proposed development, together with others in the region, will elevate the economic profile of the local communities and will result in a change in the profile of community waste streams, both in terms of quantity and the nature of the wastes. If existing waste management practices are not adapted, this could result in negative visual impacts as well as health, safety and environmental impacts around the communities.

**Mitigation measures**
- The mine could assist in the facilitation the development of an urbanisation plan for the local communities (part of the resettlement project);
- Consider options to facilitate improved management of solid waste in local communities. This may include training local communities on composting techniques or investigating and, if considered feasible, supporting recycling initiatives.

**Significance statement**
The impact would probably be of MODERATE negative significance without mitigation and LOW negative with mitigation.

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Slightly beneficial</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Beneficial</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Slight</td>
</tr>
</tbody>
</table>
7 CONCLUSION AND RECOMMENDATIONS

A review of relevant legislation and policy documents suggested that waste management in Mozambique is still in its infancy. Waste management infrastructure for the safe management of wastes is lacking in the Tete Province. This may change over time as mining and other industry enhances the economic profile of the Province but is unlikely to occur in the near future. As such, the developer should employ measures to effectively manage the waste generated from the project in order not to contribute further to poor waste management practices locally.

Based on the available project description and supplementary information sourced from a variety of sources, it was possible to make an assessment of the likely impacts associated with the management of waste streams from the proposed Tenge-Ruori iron project in Mozambique. This will, however, need to be reviewed once further detailed information on, in particular, management of process waste streams becomes available.

A total of 14 impacts were identified (Table 7.1) and of these, with mitigation, 11 were considered to be of LOW negative significance and two of MODERATE negative significance, after mitigation. One impact was considered beneficial and of Moderate significance with mitigation.

Table 7.1: Summary of the wastes related environmental impacts for the Capitol Resources Iron project

<table>
<thead>
<tr>
<th>Impact</th>
<th>Effect</th>
<th>Risk or Likelihood</th>
<th>Overall Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue 1: Disposal of waste rock and tailings (Operational phase)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long Term</td>
<td>Localized</td>
<td>Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long Term</td>
<td>Localized</td>
<td>Slight</td>
</tr>
<tr>
<td>Issue 2: Spillage of Run of Mine while Trucking (Operational phase)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long Term</td>
<td>Localized</td>
<td>Moderate</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long Term</td>
<td>Localized</td>
<td>Slight</td>
</tr>
<tr>
<td>Issue 3: Storage of process effluent in the process water pond (Operational phase)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Medium Term</td>
<td>Localized</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long Term</td>
<td>Localized</td>
<td>Slight</td>
</tr>
<tr>
<td>Issue 4: Management and disposal of slag (by-product) (Operational phase)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Medium Term</td>
<td>Localized</td>
<td>Very Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Medium Term</td>
<td>Localized</td>
<td>Very Severe</td>
</tr>
<tr>
<td>Issue 5: Management of non-process general and hazardous wastes (All phases)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long Term</td>
<td>Study Area</td>
<td>Moderate</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long Term</td>
<td>Study Area</td>
<td>Slight</td>
</tr>
<tr>
<td>Impact</td>
<td>Effect</td>
<td>Temporal Scale</td>
<td>Spatial Scale</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Impact 5.1: Pollution of land and water</td>
<td>General (Non-hazardous) wastes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long term</td>
<td>Study area</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long term</td>
<td>Study area</td>
<td>Slight</td>
</tr>
<tr>
<td>Hazardous wastes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Very Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Moderate</td>
</tr>
<tr>
<td>Impact 5.2: Nuisance impact (Production of odours, visual impact and attraction of pest and vermin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long-term</td>
<td>District</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long-term</td>
<td>District</td>
<td>Slight</td>
</tr>
<tr>
<td>Issue 6: Disposal of domestic wastewater and sewage sludge (All phases)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact 6.1: Pollution of soil and water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long-term</td>
<td>Study area</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long-term</td>
<td>Study area</td>
<td>Slight</td>
</tr>
<tr>
<td>Impact 6.2: Health impacts to employees and communities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long-term</td>
<td>District</td>
<td>Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long-term</td>
<td>District</td>
<td>Slight</td>
</tr>
<tr>
<td>Impact 6.3: Nuisance impacts (odour and flies)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Short-term</td>
<td>Study area</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Short-term</td>
<td>Study area</td>
<td>Slight</td>
</tr>
<tr>
<td>Issue 7: Disposal of run-off / storm water (All phases)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact 7.1: Pollution of land and water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Long-term</td>
<td>Study area</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Long-term</td>
<td>Study area</td>
<td>Slight</td>
</tr>
<tr>
<td>Issue 8: Regional waste profiles and community awareness (Construction and Operational Phases)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact 8.1: Local knowledge of waste management practices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Slightly beneficial</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Beneficial</td>
</tr>
<tr>
<td>Impact 8.2: Change to waste profiles in the local communities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Moderately Severe</td>
</tr>
<tr>
<td>With Mitigation</td>
<td>Permanent</td>
<td>District</td>
<td>Slight</td>
</tr>
</tbody>
</table>

It is recommended that all waste streams should be managed according to the waste management hierarchy and, as a minimum, according to Decree 13/2006, of 15 July: Regulation of Waste Management. This specifies that wherever possible, production of wastes should be prevented or minimised at source. Where prevention or further minimization is not possible, wastes should be
re-used, recycled and then disposed of responsibly so as to minimise impacts to the environment. Further guidance on the management of waste streams is provided in the IFC General EHS Guidelines (2007) and the IFC EHS Guidelines for Mining (2007). In the event that there are no national standards available, the proponent must comply with internationally recognised standards developed by international organisations such as the IFC. In the case where there are several standards available for use, the proponent must provide justification for the choice of use, other than the use of the most stringent.

Due to the local situation as per the remote location of the project site and relevant legislation, it is recommended that the proponent establish a general (non-hazardous) waste disposal facility on the site. The report provides detailed guidance on the selection of candidate sites for the on-site general waste landfill.

Alternative options will need to be considered for the management and disposal of hazardous wastes. These would be to either develop a dedicated and specially-designed hazardous waste cell within the new on-site landfill or, alternatively, to construct a bunded and secure facility for temporary storage of hazardous waste on site until such time as it can be transported off-site for safe disposal. Although the only existing hazardous waste landfill in Mozambique is located in Maputo, there is an indication that new hazardous waste disposal facilities are in the process of being developed closer to the project site, including one in Tete Province, and disposal of hazardous waste at that facility should be regarded as the preferred option.
REFERENCES


Bankable Feasibility Study Scoping Study (2012): Environmental and Social Balama Graphite Project


Craig Vogt (2012): International Assessment of Marine and Riverine Disposal of Mine Tailings


Environmental Protection Agency (2000): Landfill Manuals - Landfill Site Design


International Committee of the Red Cross (2011): Medical Waste Management


International Finance Corporation (2012): Performance Standards on Social & Environmental Sustainability


World Bank Technical Paper No. 426
## APPENDIX A: SANITARY EFFLUENT STANDARDS

<table>
<thead>
<tr>
<th>Pollutant/Measure</th>
<th>Units</th>
<th>MICOA</th>
<th>IFC Gen. EHS (2007)</th>
<th>AfDB</th>
<th>Most Stringent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Present / Absent</td>
<td>1:20 dilution</td>
<td>-</td>
<td>-</td>
<td>Absence</td>
</tr>
<tr>
<td>Smell</td>
<td>Present / Absent</td>
<td>1:20 dilution</td>
<td>-</td>
<td>-</td>
<td>Absence</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>mg/l</td>
<td>60</td>
<td>50</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>pH</td>
<td>S.U.</td>
<td>6-9</td>
<td>6-9</td>
<td>-</td>
<td>6-9</td>
</tr>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>150</td>
<td>125</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/l</td>
<td>-</td>
<td>30</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>mg/l</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/l</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>mg/l</td>
<td>10 (y)</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total Coliform bacteria</td>
<td>MPN/b/100ml</td>
<td>-</td>
<td>400 (a)</td>
<td>400 (q)</td>
<td>400</td>
</tr>
<tr>
<td>Temperature increase</td>
<td>°C</td>
<td>35°(z)</td>
<td>-</td>
<td>-</td>
<td>35°</td>
</tr>
</tbody>
</table>

*a: Not applicable to centralized, municipal, wastewater treatment systems which are included in EHS Guidelines for Water and Sanitation

*b: MPN = Most Probable Number

*y: 3 mg/l in sensitive zones

*z: Increase at the receiving medium

*q: Water used for irrigation
# APPENDIX B: PROCESS EFFLUENT STANDARDS (MINING AND IRON)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>mg/l</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.5</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/l</td>
<td>0.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>0.4</td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/l</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td>Berelium</td>
<td>mg/l</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>1.5</td>
</tr>
<tr>
<td>BOD</td>
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<td>50</td>
<td>50</td>
<td>-</td>
<td>&lt;5</td>
<td>5</td>
</tr>
<tr>
<td>Boron</td>
<td>mg/l</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Cadmium</td>
<td>mg/l</td>
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<td>0.01</td>
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<td>Chromium (Total)</td>
<td>mg/l</td>
<td>-</td>
<td>0.5</td>
<td>1</td>
<td>-</td>
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<td>100</td>
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<td>100</td>
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<td>1</td>
<td>1</td>
<td>-</td>
<td>0.005</td>
</tr>
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<td>Cyanide (Total)</td>
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<td>Cyanide WAD</td>
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<td>-</td>
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<td>-</td>
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<td>dissolved oxygen</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>≤ 6</td>
</tr>
<tr>
<td>Floating material</td>
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<td>Absent</td>
<td>-</td>
<td>-</td>
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<td>Absent</td>
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<td>Fluorides</td>
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<td>-</td>
<td>-</td>
<td>5</td>
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<td>1</td>
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<td>0.5</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Mercury</td>
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<td>0.01</td>
<td>0.01</td>
<td>0.002</td>
<td>0.01</td>
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<td>0.5</td>
<td>0.1</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
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<tr>
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<td>-</td>
<td>-</td>
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<td>Nitrogen</td>
<td>mg/l</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>-</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td></td>
<td></td>
<td>Present / Absent</td>
<td>15</td>
<td>20</td>
<td>10</td>
<td>Absent</td>
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<tr>
<td>Poly-aromatic Hydrocarbons (PAH)</td>
<td>mg/l</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>pH</td>
<td>S.U.</td>
<td>6.5 - 8.5</td>
<td>6 - 9</td>
<td>6 - 9</td>
<td>6 - 9</td>
<td>6 - 9</td>
<td>6 - 9</td>
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<tr>
<td>Phenols</td>
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<td>0.02</td>
<td>-</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>Phosphorous</td>
<td>mg/l</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Residual chlorine</td>
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<td>0.01</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td>Selenium</td>
<td>mg/l</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td>Silver</td>
<td>mg/l</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.005</td>
</tr>
<tr>
<td>Substances that react with methylene blue</td>
<td>mg/l</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Sulphide like hydrogen disulphide</td>
<td>mg/l</td>
<td>0.002</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
<td>0.002</td>
</tr>
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<td>----------------</td>
</tr>
<tr>
<td>Temperature</td>
<td>° C</td>
<td>-</td>
<td>&lt;3° differential</td>
<td>-</td>
<td>&lt;3° differential</td>
<td>&lt;3° differential</td>
<td>&lt;3° differential</td>
</tr>
<tr>
<td>Tin</td>
<td>mg/l</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>mg/l</td>
<td>-</td>
<td>15</td>
<td>-</td>
<td>50</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Uranium</td>
<td>mg/l</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/l</td>
<td>0.01</td>
<td>2</td>
<td>-</td>
<td>0.5</td>
<td>2</td>
<td>0.01</td>
</tr>
</tbody>
</table>
## APPENDIX C: SOIL STANDARD

<table>
<thead>
<tr>
<th>Pollutant/Measure</th>
<th>Units</th>
<th>AfDB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/kg</td>
<td>-</td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/kg</td>
<td>-</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/kg</td>
<td>-</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/kg</td>
<td>-</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/kg</td>
<td>-</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/kg</td>
<td>-</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/kg</td>
<td>-</td>
</tr>
<tr>
<td>Bromine</td>
<td>mg/kg</td>
<td>20</td>
</tr>
<tr>
<td>Cyanides (total free)</td>
<td>mg/kg</td>
<td>1</td>
</tr>
<tr>
<td>Fluorides</td>
<td>mg/kg</td>
<td>-</td>
</tr>
<tr>
<td>Sulphide</td>
<td>mg/kg</td>
<td>2</td>
</tr>
<tr>
<td>Benzene</td>
<td>mg/kg</td>
<td>0.05</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>mg/kg</td>
<td>0.05</td>
</tr>
<tr>
<td>Toluene</td>
<td>mg/kg</td>
<td>0.05</td>
</tr>
<tr>
<td>Xylene</td>
<td>mg/kg</td>
<td>0.05</td>
</tr>
<tr>
<td>Phenols</td>
<td>mg/kg</td>
<td>0.05</td>
</tr>
<tr>
<td>Total hydrocarbons</td>
<td>mg/kg</td>
<td>-</td>
</tr>
</tbody>
</table>

A: Reference value, no pollutant
B: Value for further investigations
C: Value for remedial action
APPENDIX D: GUIDANCE ON THE DEVELOPMENT OF AN ON-SITE LANDFILL

1 Introduction

The design and construction of the Capitol Resources waste landfill site should be in accordance with international best practice as described in EPA (2000), details of which have been provided in the Minimum Requirements for Waste Disposal by Landfill, 3rd ed. (DWAF, 2005).

Mozambique has no specific requirement for the siting, designing and constructing a general waste landfill site. According to the Article 7(I) of Decree No. 13/2006, of 15 June (Regulations on Waste Management) “All public or private entities carrying out activities related to solid waste management should prepare their waste management plan, prior to entering into business, which should contain at least, information required in Annex I and/or Annex II, in case it is, respectively, a landfill or another waste management operation”.

The purpose of this Appendix is to provide preliminary guidance on the design and site selection considerations should Capitol Resources decide to develop a non-hazardous landfill on site.

2 Permitting

“Facilities and equipment meant for disposal, treatment, utilization, valorization or elimination of waste are subject to environmental licensing, in accordance with the regulations on the process of environmental impact assessment …” (Article 10(1) of Decree No. 13/2006).

Appendix I(4.8a) of Decree no. 45/2004 (as amended by Decree No. 42/2008), “Places for disposal of Municipal waste with a load greater than 500 tonnes per day” requires an EIR for licencing. The estimated quantity of general solid waste generated by the proposed mining operation will be significantly less than this threshold. It is therefore expected that a Simplified Environmental Report (SER) covering this facility will need to be submitted to MICOA [as per Appendix II of Decree no. 45/2004 (as amended by Decree No. 42/2008)] to support the application for a landfill license.

Due to the limited information on the proposed facility, it is not possible to assess the full environmental impact of such a facility at this stage.

3 Landfill classification

The classification of a landfill will determine specific requirements in terms of design and management of the facility. Landfills may be grouped according to the following characteristics (DWAF 2005):

- the type of waste to be disposed
- the volume of the waste stream, and
- the potential for significant leachate generation.

The likely classification of the landfill at the Baobab mine, based on these characteristics, is discussed below.

3.1 Waste type

It has already been established that the objective would be to establish a landfill facility on site for the disposal of non-hazardous (general) waste. This is therefore designated as a ‘general’ (G) landfill. Disposal of hazardous waste (other than small quantities of hazardous materials normally associated with household garbage) is not permitted in such a facility.
3.2 Volume of waste

The ultimate physical size of the proposed general waste landfill site will depend on the amount of waste it receives over its lifetime. This is important in the context of a point source of pollution, and should therefore be addressed when undertaking the environmental assessment for the selected site.

The size of operation depends on the daily rate of waste deposition. This in turn relates to, amongst other things, the size of the population served. To take time and growth into account, disposal sites are classified using the ‘Maximum Rate of Deposition’ or ‘MRD’. This is simply the projected maximum average annual rate of waste deposition, expressed in tonnes per day, during the expected life of the site. This calculation requires estimates of the initial rate of deposition and expected annual escalation in waste production.

Based on an IRD of <1ton/day (see section 5.3.2) and the DWAF (2005) landfill size classification (Table A5-1), it is expected that the proposed landfill will be classified as “communal” (C). This is the smallest classification category and is associated with the least number of design and operational requirements.

Table A5-1: Landfill Size Classification (DWAF 2005)

<table>
<thead>
<tr>
<th>Disposal Site Size Class</th>
<th>Maximum Rates of Deposition (Tonnes per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communal Landfill Site ‘C’</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Small Landfill Site ‘S’</td>
<td>&gt;25</td>
</tr>
<tr>
<td>Medium Landfill Site ‘M’</td>
<td>&gt;150</td>
</tr>
<tr>
<td>Large Landfill Site ‘L’</td>
<td>&gt;500</td>
</tr>
</tbody>
</table>

3.3 Leachate production potential

All landfills have the capacity to generate sporadic leachate in excessively wet weather conditions, as such the potential for significant or sporadic leachate generation be assessed and any need for leachate management identified prior to considering a site for the location of landfill.

Three factors are considered in determining whether significant leachate will be generated and if leachate management is required by a landfill site. They include the Site Water Balance, the Climatic Water Balance and the Site Specific Factors.

The Site Water Balance is affected by such factors as rainfall, evaporation, moisture content of incoming waste and water ingress into the waste body on account of poor landfill site selection, design and operation. Of these, however, the relationship between rainfall and evaporation will, as a general rule, determine the Site Water Balance.

As ambient climate is the major uncontrollable cause of significant leachate generation at a landfill, a Climatic Water Balance is used as the first step in determining the potential for significant leachate generation. “The Climatic Water Balance is a relatively simple and conservative calculation that assists in deciding whether a landfill is likely to generate leachate” (DWAF, 2005). If so then this must be considered during the design of the facility. The Climatic Water Balance is calculated according to the following formula:

1 ton = 1.016tonne. NEMA WA refers to “Ton” while the DWAF 2005b refers to Tonnes. For the purpose of this report 1tonne has been equated to 1ton.
B = rainfall (R) in mm of water – evaporation from soil (E) in mm water

The value of B is calculated for the wet season of the wettest year on record and then also recalculated for successively drier years. The results of the calculation will determine the classification of the landfill in terms of potential to generate leachate, where:

B is positive for less than one year in five for which data is available: B⁻ (no leachate likely); or
B is positive for more than one year in five for which data is available: B⁺ (leachate likely)

Site-Specific Factors include the expected waste moisture content, and ingress of runoff and ground water into the waste body.

The climate of the project area is considered sub-tropical, with a mean annual rainfall of 1000mm. January is traditionally the wettest month, with a mean rainfall of 229mm while rainfall in the driest months of August and September are 6mm and 5mm, respectively. Although no site-specific evaporation data is available, it is expected that due to the distinct wet season that the site would be classified as B⁺. Consequently, the design of the facility would need to include leachate management systems.

3.4 Overall classification

Based on the above, the landfill site at the mine would most likely be classified as: GCB⁺

4 Landfill siting

Disposal site selection is the fundamental step in the development of a landfill site. This step has far reaching economic, environmental and public acceptance implications. The site selection process is only complete once the MICOA has confirmed a site feasible on the basis of an environmental assessment.

The objectives of disposal site selection are:

- To ensure that the site to be developed is environmentally acceptable and that it provides for simple, cost-effective design, which in turn provides for good operation.
- To ensure that, because it is environmentally acceptable, it is also socially acceptable.

The first step of the process involves identification and ranking of candidate landfill sites. It is important to ensure that this process is conducted in a logical manner and that all relevant information is available. The specific area of each candidate site will be determined by the required size of the landfill which, in turn, is dependent on the Maximum Rate of Deposition and expected life of the landfill.

Once the area of the site has been determined, the following steps need to be followed in order to identify candidate sites:

- Elimination of all areas with Fatal Flaws
- Identification of candidate sites based on key criteria
- Ranking of candidate sites

4.1 Elimination of Fatal Flaws

No landfill should be developed in areas with an inherent fatal flaw. Based on the DWAF (2005) guidance documents, these include the following:

- 3 000m from the end of any airport runway or landing strip in the direct line of the flight path and within 500m of an airport or airfield boundary;
- Areas below the 1 in 50 year flood line;
Potential areas within the mine lease that exhibit any of the above fatal flaws must be excluded from further consideration as potential sites for the landfill.

### 4.2 Identification of candidate sites

After exclusion of areas associated with potential fatal flaws, it will be possible to identify candidate sites using a range of economic, environmental and social criteria. As a general rule, sufficient candidate sites should be identified to ensure the due consideration of alternatives.

#### Economic criteria

For the purposes of the current project, consideration of certain of the recommended economic factors is not considered essential as this is more applicable to landfills servicing urban areas. However, the following factors should be considered:

- Access to the landfill site, in particular, the need for additional access roads;
- The ready availability of cover material (daily covering is essential for the operation of the site);
- Local soil quality (availability of low permeability clayey soils may reduce the cost of containment liners and leachate management systems)

#### Environmental criteria

These criteria relate to impacts on the biophysical environment, in particular, water resources. The following should be considered:

- Distance to ground water (the greater the distance, the better);
- The importance of ground or surface water as a resource;
- The depth of soil on the site (the greater the availability, the better as this is required as cover material);
- The quality of on-site soil (low permeability soil will reduce pollutant migration);
- Valleys where temperature inversion could occur (this could promote the migration of landfill gas and odours into populated areas);
- The sensitivity of the receiving environment.

**Social criteria**

According to the DWAF (2005) guidelines, these public / social criteria relate mostly to issues of health, quality of life, local land values and the likely resistance of communities to the landfill. The following social criteria should be considered during the identification of candidate sites:

- Displacement of local inhabitants (*note: unlikely to be relevant to the current project*);
- Exposed sites with high visibility are undesirable;
- The sensitivity of the access road(s) from a social perspective (e.g. proximity to houses);
- Prevailing wind directions;
- Distance from the nearest residential area.

Related to the last consideration, to protect the public from any adverse effects of a waste disposal operation, adequate buffer zones must be established. An additional benefit of maximising the distance between a landfill site and local community is the reduction in the practice of “picking” where community members gain access to the disposal site to search for items of value or food. Discouraging these activities through erection of physical barriers, such as fences, can be costly and ineffective.

**4.3 Ranking of candidate sites**

Once a number of suitable candidate sites have been identified then it will be necessary to rank the sites based on key criteria. This ranking exercise could involve a matrix, an example of which is shown in Table A5-2. The criteria used should be appropriately weighted in order to reflect their relative importance. For example, proximity to water resources may be scored out of 20 whereas access may only be scored out of 5. When using the matrix, each site is evaluated and scores are assigned for each criterion and added together to provide a total for each site. Thereafter, sites are ranked from the highest to the lowest.

**5 Detailed Environmental Assessment**

The top sites based on this process should then be subject to a detailed environmental assessment to identify the preferred site. In order to complete this assessment, it will be necessary to have prepared conceptual designs for the facility.

Mozambique has no specific requirement for the siting, designing and constructing a general waste landfill site. However, according to the Article 7(I) of Decree No. 13/2006, of 15 June (Regulations on Waste Management) “All public or private entities carrying out activities related to solid waste management should prepare their waste management plan, prior to entering into business, which should contain at least, information required in Annex I and/or Annex II, in case it is, respectively, a landfill or another waste management operation” (see Table A5-3 of this report).
<table>
<thead>
<tr>
<th>Candidate Site</th>
<th>Economic Criteria</th>
<th>Environmental Criteria</th>
<th>Public Acceptance Criteria</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance</td>
<td>Size</td>
<td>Available areas for buffer zone</td>
<td>Access</td>
</tr>
<tr>
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<td></td>
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</tr>
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<td>Site 2</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Site n</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table A5-3: Mozambican Regulations on Waste Management (Decree 13/2006 of 15 June)

ANNEX I

LANDFILLS

I. WRITTEN PARTS

A. descriptive document and Justification

a) the Purpose of the project.
b) planning, site selection and Project bases, including volume and area occupied.
c) geotechnical and hydrogeological, geological features of the site;
d) typology and amount of waste;
e) risk management processes;
f) observing procedures for the prevention and minimization of waste production;
g) techniques, equipment and procedures to be observed for the treatment of waste;
h) location and characteristics of the place for storing of waste, as well as storage procedures, including information on the type and characteristics of the storage containers;
i) type, characteristics of transport means and procedures to be observed for the carriage of waste, from the point of his generation to the place of their disposal;
j) procedures to observe for the deposition or disposal of waste;
k) waterproofing system;
l) stormwater drainage systems and leachate;
m) leachate treatment, forecasting the quantity and quality of leachate;
n) leachate and groundwater monitoring in order to prevent contamination of groundwater;
o) drainage and treatment of biogas, if necessary;
p) business plan of the landfill;
q) staff structure and schedule of work;
r) and populations safety plan system workforce;
s) waste acceptance plan;
t) waste collection plan;
u) final coverage, landscape recovery and post closure monitoring;
v) procedures in case of accidents, oil spills. Discharge and accidental leaks;
w) means and responsibilities for carrying out the activities set out in the waste management plan.

B. Sizing

a) the calculation and dimensioning of barriers for waterproofing;
b) scaling and calculations of leachate treatment plant.

II. PARTS DESIGNED

A. plant location (1:25 000 scale)

B. General Plan of the landfill, with clear indications of all infrastructure components, including implementation of waste disposal and the pre-treatment;

C. Details of stratigraphy of waterproofing and final coverage of the landfill.