NORTH RIVER NAMIB LEAD / ZINC
PROJECT
FEASIBILITY STUDY
Volume 1

Section: 2 Introduction and Project Background
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1 INTRODUCTION

1.1 Objectives of Study

- To design a “fit for purpose” plant, for Namibian conditions, to produce 60+% lead concentrate and 50+% zinc concentrate from fresh ore, and 50+% zinc from old tailings.
- To determine the commercial and technical feasibility of the project if developed and operated as per design.
- To present a concept with a viable technical design and associated costs that will be sufficient for a budget estimate and possible approval of the subsequent execution stage.
- To develop and present ±15% accuracy level Capex and Opex estimates in accordance with client directives
- To develop an execution phase schedule for indicating key activities and the critical path
- Integrate related studies by other consultants into the design as necessary, inclusive of resource estimation, mine planning and development and tailings storage facility design.

1.2 Project Background

North River Resources (NRR) wish to re-open their flagship Namib Lead-Zinc mine in Namibia. The Namib lead/zinc project is located in the Namib Desert approximately 30km north-east of Swakopmund, as illustrated in Figure 1. North River Resources (Namibia) (Pty) Ltd is planning to start re-working the existing mine dump and re-start mining activity. The mine was recently pumped out after more than 20 years of abandonment. Development of the Namib lead/zinc project will comprise of a brownfields lead-zinc ore receiving, crushing, milling, flotation, dewatering of tailings and concentrates and reagents.
A target production rate of 250,000 tonnes per annum is envisaged, producing both lead and zinc concentrates, with lesser amounts of other metals such as silver. From their resource estimate, North River Resources expect a minimum life of mining and processing of seven years.

Figure 1 – Project location

1.3 Study Approach
The flowsheet for this study was based on previous studies, as supplied by North River Resources. Full test results on which to base the design were not available at the project start and as a result, design and specification assumptions were initially made and agreed upon at the project kick-off
Tenova Bateman SSA
Tenova Mining & Minerals

workshop. The assumptions were based on a review of all previous testwork and studies, and were modified by Tenova Bateman during the course of the study as more recent testwork results were received.

Process design was based on the treatment of fresh ore from underground. Provision was made for the re-processing of old tailings and subsequent recovery of latent zinc, although flowsheet optimisation was centred on fresh ore throughput. The mass balance was prepared by Tenova Bateman and formed the basis for determining equipment sizes.

The Capex estimating philosophy is in line with the invitation to bid (ITB) document, with greater levels of accuracy being achieved in some areas.

- Budget quotes for all mechanical equipment greater than $10k and in-house data for minor mechanical equipment
- Budget quotes for major packages
- Budget quotes for major electrical items (Gent-sets, switchgear etc.)
- Sketches and GA take-offs for structural steel and concrete. Rates for bulk steel and concrete to be in accordance with quoted rates for the region
- Bills of quantity (BOQ’s) electrical cabling were based on take-offs from detailed mechanical layouts.
- Factoring based on equipment list for instrumentation
- Piping bills of materials were based on take-offs from the piping layout which contained single line routings supported by the PFD’s. The PFD’s were redlined with preliminary line numbers and valves to be able to control the BOQ’s. Factoring based on similar facility designs for small utility lines and reagent tubing
- EPCM to be factored in line with industry experience.
Comparative budget pricing for major equipment will include a minimum of 2 quotes, but preferably three. A budget price is defined as an estimated cost that rarely takes into account firm specifications or commercial terms and conditions.

North River provided an operating cost estimate template which mirrors accepted engineering practice. The operating cost estimating methodology includes:

- Labour – organization chart and local rates
- Power – consumptions as contained in the electrical load list
- Reagents – budget quotes including freight to site
- Consumables – budget quotes including freight to site
- Maintenance – based on a percentage of capital cost/annum
- General and Administration – including administration staff, legal fees and recruitment
- Product Transport

The level of detail for project definition was prescribed by North River Resources. Based on their calculations, the accuracy of the estimate is in the range of ±15% accuracy.

1.4 High Level Project Description

1.4.1 General Overview

The Namib Lead-Zinc mine has been developed by North River Resources since early 2010. The underground mine has been dewatered and surveyed, and is ready for further development. North River proposes to re-open the old underground mine and construct a new lead/zinc processing facility for treating 250,000 tpa of run-of-mine (ROM) material.
Most of the surface infrastructure from the previous operations has been either removed or destroyed, or is unfit for incorporation and utilization in the new processing facility. Although the processing plant is optimally designed for treating ROM ore, it is also suited for retreating the old tailings dump material and subsequent recovery of zinc.

Tenova’s scope of work consists of the following major components:

- New Processing Plant
- Tailings disposal
- Infrastructure.

Refer to Appendices for a detailed process description of the plant. Below is a brief description of the plant and infrastructure.

1.4.2 New Processing Plant

The new processing facility is to be constructed on the same plot area as the previous plant. The plant footprint is approximately two-hundred and fifty metres long by one hundred metres wide.

ROM pad and Ore Stockpiling

The ROM material will be transported to the pad by mining vehicles. The vehicles will tip ROM material onto designated areas of the two-thousand tonne stockpile. Selected ore will be transported from the stockpile and fed to the feed hopper by front end loader.

When required, old tailings material will be fed to the plant. Tailings material will be stockpiled near the mobile crusher and fed directly to the crusher hopper by front end loader.
**Crushing**

The crushing circuit comprises a single stage impact crusher and screen. In order to reduce the amount of redundant equipment, Tenova propose two different crushing options, depending on the processing directive from North River:

**Option 1: Tailings and Fresh ore throughput**

A mobile crusher is the best option if the plant will treat old tailings and fresh ore. The crusher is a diesel powered, track mounted, single stage impact crusher and screen. Product is fed to the mill. Its mobility enables it to be stationed and operated near the old tailings dump during tailings reprocessing. The rig can be driven and parked below the ore feed bin for processing of fresh ROM material. This is fed into the three-hundred tonne fine ore bin.

**Option 2: Fresh Ore only throughput**

For processing of fresh ore only, a modular skid mounted crushing circuit appears to be the better option. ROM material is fed onto a static grizzly and hopper, which then feeds into a single stage impact crusher and closed circuit single deck vibrating screen. Product is fed into the three-hundred tonne fine ore bin.

**Milling**

Material from the fine ore bin is fed onto a conveyor, which in turn feeds the mill. A conventional overflow ball mill was selected because of its simple and robust design when compared to a grate discharge mill. The design is based on a throughput of 32tph and target grind of 80% passing -75 microns. In order to generate a narrow particle size distribution for the flotation feed, the ball mill is in closed circuit with a hydrocyclone and circulating load of 250% as a suitable compromise between efficient milling and the size of the mill discharge pumps.
It should be possible to reprocess tailings at a substantially increased plant throughput. A nominal capacity of 300 000 tpa has been chosen as a reasonable compromise between throughput and recovery, but this could easily be exceeded (with potential loss of recovery).

**Flotation**
For the processing of fresh ore, the cyclone overflow reports the lead conditioner. After the addition of reagents, the slurry reports to the lead flotation cells where a lead concentrate (+60% Pb) is produced. The residual slurry is pumped to the zinc conditioner.
Further reagents are added and the slurry reports to the zinc flotation cells. Zinc concentrate (+50% Zn) is produced and the tailings are pumped to the dewatering circuit.

In the event of the reprocessing of reclaimed tailings material, the cyclone overflow will report directly to the Zinc conditioner, bypassing the lead flotation circuit.

**Concentrate Handling and Tailings Dewatering**
The lead and zinc concentrates report to their respective filter presses. Filter cake is manually discharged from the presses. Lead concentrate is immediately collected and transferred to the dispatch container. Zinc concentrate is moved to the five-thousand tonne stockpile area. It is covered by tarpaulins until loading into a container.
Tailings from the flotation circuit reports to the thickener for dewatering. While the thickener overflow reports to the process water tank, the thickener underflow is pumped to an intermediate sump before being discharged to the tailings storage facility.
Tailings Storage Facility (TSF)
Tailings slurry is pumped to a purpose built storage dam. Water is recovered from the dam and returned to the process plant for re-use.

Mobile Fleet
Mobile fleet requirements for the processing plant include a front-end loader, two telescopic handlers (telehandlers) and a bakkie. These will service all normal processing plant requirements. The mining workshop (out of Tenova scope) will take care of fleet maintenance.

1.4.3 Infrastructure
There are no existing utilities on the plant. The only existing infrastructure comprise of roads in and around the plant, and workshop walls.

Electricity
Power will be supplied via an existing line from the national grid. Electrical infrastructure feeding the site requires a complete overhaul and old poles need repair. The 7km 33kV line must also be extended a further 150m. It is not yet clear whether sufficient power can be supplied by the ErongoRED utility company (a subsidiary of Nampower) for the fully developed project. However, if sufficient power is not available, diesel generators will be installed. At present North River Resources do not foresee any problems receiving adequate power.

Water
Raw water to site will be supplied using a new 110mm pipeline on an existing route, from an offtake on the Swakop – Rössing Mine pipeline. This off-take point is located 7km from site. A pipeline with the necessary valves and instrumentation will be laid and will deliver sufficient water for both processing plant and mining operations. A water surplus is available from Areva’s desalination plant. According to previous studies, an existing
A borehole on site can also be pumped to provide non-potable saline water suitable for drilling activities.
North River Resources also do not foresee any water supply problems from Namwater.

**Workshop**
There is a brick and mortar structure, but the roof needs rebuilding. Once refurbished, this will be utilized as a workshop for the processing plant. It will then house tools and processing plant spares.
A workshop for servicing of the mobile fleet is being constructed by the mining consultants and is out of Tenova's scope.

**IT and Communications**
Cellular phone signal is available on site. However, a datalink satellite must be installed to provide a permanent and dedicated communications link. All IT infrastructure would need to be set-up, inclusive of computers, printers, etc. It is foreseen that construction teams would utilize hand-held and mobile phones.

**Offices and Change houses**
Fully equipped containerised offices will be used for management and administration staff. Similarly, changehouses will be containerized, fully equipped units servicing both mining and processing plant workforces.

**Diesel Storage**
Diesel will be stored above ground and within a double bunded container specifically designed for diesel storage and offloading. The storage facility caters for refuelling of the mining fleet as well as providing fuel for the emergency generator set.
1.5 Site Information

1.5.1 Site Location and Access

The Namib Lead-Zinc concession, EPL 2902 (Figure 2) is situated in the Dorob National Park, west of Rössing Mountain. It lies between Swakopmund (23km) and Arandis (34km). A gravel road of 8km leads northwards off the B2 national road to the mine. There are no permanent residents in or close to the EPL or ML areas. The nearest residents are along the Swakop River, which is to the south of the EPL.

Figure 2 – Orthophoto Map: EPL 2902 & proposed Licence area (Colin and Associates, 2013)

Namib Lead Zinc site GPS coordinates are:

- Latitude: 22°31’17.53’S
- Longitude: 14°45’41.16”E
o The site altitude is approximately 280 m AMSL, with a variation in elevation of approximately 200 m within the Exclusive Prospecting Licence (EPL) 2902 area.
o The mine site itself has a relative flat topography with a slight fall towards the west.

Air travel to Namibia can be done to either Windhoek or Walvis Bay. The latter being the more convenient for direct access to site. Walvis Bay is also a large port with well-established dockyards and related industries.

No housing will be provided at the mine, but workers will be transported by bus from Swakopmund. The mine will operate 24 hours per day, seven days per week – three work shifts per day. Only a few security personnel will be accommodated on site.

1.5.2 Meteorology

Data from the nearest weather station (close to the Namib Lead Mine) was available only for the three year period from January 2009 till December 2011. Typical temperatures ranged from 5 °C to 40 °C with the highest daily temperature recorded in March and lowest in June. The hottest month is normally February with August being the coolest. Running counter to this trend, high daily temperatures occur during the late winter and spring when easterly winds are associated with the subsiding air from the interior of the country.

The area is characterised by extreme aridity of the Namib Desert. Average rainfall values are not very helpful because of its variability. It is quite common to experience no rainfall during a particular year (or more), while experiencing the annual average in a single event in another.
Since Namib Lead & Zinc Mine is roughly midway between Rössing and Swakopmund, SLR (Oct, 2013) interpolated between these two sets of data to estimate the monthly rainfall at the mine – shown in Table 1 below. The mean annual rainfall for the mine was thus estimated at 21.7mm.

**Table 1 Mean Monthly Rainfall for the Region: 1984 to 2002 (mm) (SLR, Oct 2013)**

<table>
<thead>
<tr>
<th>MONTH</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rössing Mean (mm)</td>
<td>3.7</td>
<td>4.0</td>
<td>11.0</td>
<td>4.3</td>
<td>1.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.2</td>
<td>0.7</td>
<td>0.4</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Swakopmund Mean</td>
<td>1.7</td>
<td>1.5</td>
<td>4.6</td>
<td>2.5</td>
<td>0.7</td>
<td>1.1</td>
<td>1.1</td>
<td>0.3</td>
<td>0.0</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Average Namib Mine</td>
<td>2.7</td>
<td>2.7</td>
<td>7.8</td>
<td>3.4</td>
<td>1.1</td>
<td>0.8</td>
<td>0.4</td>
<td>0.4</td>
<td>0.1</td>
<td>0.5</td>
<td>0.4</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Available wind data, compiled by Airshed (2013), is represented as wind roses and shown below. The wedge shapes show the wind direction. Colours represent wind speeds. The first wind rose in **Figure 2** shows the winds for the entire two year recording period, while the second and third wind roses show the difference between day and night – with strong westerly winds being common during the day and northerly or westerly winds at night.

**Figure 3** shows the seasonal wind roses. Spring and summer generally show higher wind speeds, with directions varying between north and southwest. Autumn and winter are much calmer, except when easterly winds occur. The yellow to red colours show that these easterlies are strongest. Since easterly winds are also very warm and dry, they are responsible for more wind erosion and dust dispersion than winds from the other directions. This was confirmed by the study by Linus (2010) on contamination of soils by dust containing metals. Linus found that levels of contamination were higher downwind of the old mine and tailings in a west–southwesterly direction.
Thus it is the easterly winds that are of greatest concern for dust dispersion. Note that the wind roses in **Figure 3 and Figure 4** below are based on three years’ data only and therefore may not necessarily accurately represent average wind directions over a longer period. They do however indicate the dominant trends.

![Wind Rose Diagram](image)

**Figure 3 - Period wind rose for the Namib lead/zinc site (Jan 2009 – Dec 2011)**
1.5.3 Seismicity

A survey of literature on seismicity in Africa yielded a map that delineates Namibia in terms of peak ground acceleration (PGA) for OBE events. The location of the Namib Lead/Zinc Plant in relation to a seismic zoning map is shown in Figure 5. This seismic zoning map indicates that the site is located in an area of low seismic hazard with an expected maximum peak ground acceleration (PGA) of between 0.02 and 0.08g (WHO Earthquake Hazard Map for Namibia) with the equivalent Richter (≤6) and Modified Mercalli Scale (≤VII) categories.
1.5.4 Geotechnical Survey

Geotechnical surveys are available from the client if required.

1.6 Scope of Work

Tenova Bateman’s technical scope of work included:

- A review of previous studies and testwork, followed by the generation of an agreed base-line Process Design Criteria (PDC). Thereafter, further advancement of the PDC, based on supervised testwork.
results, permitted the development of a technically viable design as well as associated cost estimate.

**Testwork Supervision**
- The aim of the testwork was primarily to confirm ore characteristics and key process design criteria.

**Process Plant**
- Run of mine (ROM) ore receipt and storage area.
- Crushing plant for throughput of both encrusted tailings and fresh ore.
- A 300 tonne fine ore storage bin to provide a steady feed of crushed ore to the mill.
- A 450kW ball mill with hydrocyclone for achieving grind size suitable for flotation.
- Lead sulphide flotation circuit, including roughers, cleaners and re-cleaners.
- Zinc sulphide flotation circuit, including roughers, cleaners and re-cleaners.
- Flotation residue dewatering and pumping.
- Lead concentrate filtering for cake (concentrate) dewatering.
- Zinc concentrate filtering for cake (concentrate) dewatering.
- Stockpile area for 5,000t zinc concentrate.

**Infrastructure and Plant Services within the plant boundaries:**
- Reagent supply and storage.
- Plant water systems (including potable water distribution).
- Transformer, MCC and power distribution.
- Emergency power supply.
- Compressed air systems.
- Re-use of existing site buildings, plus new site buildings including plant offices.
• Fire protection and fire water reticulation.

*Infrastructure and Plant services outside the plant boundary*

• Raw water supply from the Swakop – Rössing water supply line 7km away.
• Routing and costing of the overhead power supply line from the 33kV T-point 7.4km away.
• Change-house for both plant and mining personnel.
• Tailings storage facility (TSF) to be designed by others, but pumping tailings to the TSF and pumping back return water in Tenova Bateman's scope.

### 1.7 Design Criteria

The following acts and regulations were used as the basis of the design of projects structures and equipment:

- South African Occupational Health and Safety Act (act 85 of 1993 as amended) (OHS Act)
- Mine Health and Safety Act, Act 29 of 1996 (MHS Act)

The following codes and regulations were applied:

- Applicable South African National Standards or British Standard Specifications and Codes of Practice.
- ISO, American or British standards (where possible) for internationally supplied equipment
- Other applicable International Standards, Specifications and Codes of Practice (subject to approval).
Where discrepancies exist between requirements and referenced codes or regulations, then the most onerous requirements were applied.

1.8 Study Participants

The study was completed by an integrated team under the guidance of the following main members:

Table 2 – Project study team

<table>
<thead>
<tr>
<th>Name</th>
<th>Qualifications</th>
<th>Discipline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Martin French</td>
<td>Executive Director</td>
<td>London, UK</td>
</tr>
<tr>
<td>Dominic Claridge</td>
<td>Project Manager</td>
<td>London, UK</td>
</tr>
<tr>
<td>Dick Joubert</td>
<td>Project Sponsor</td>
<td>Tenova Bateman</td>
</tr>
<tr>
<td>Donavan King</td>
<td>Study Manager</td>
<td>Tenova Bateman</td>
</tr>
<tr>
<td>Myles Smith</td>
<td>Lead Process Engineer</td>
<td>Tenova Bateman</td>
</tr>
</tbody>
</table>