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Dundee Precious Metals Inc. Tsumeb
ESIA Amendment Process for the Proposed Tsumeb
Smelter Upgrade and Optimisation Project:
Environmental Impact Assessment Report

SLR Project No.: 734.04040.00008

Report No.: 1

April 2017



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CONSULTANT CONTACT DETAILS

Project Manager	Eloise Costandius
Project Manager e-mail	ecostandius@slrconsulting.com
Author	Eloise Costandius
Reviewer	Werner Petrick
Branch	Swakopmund
Postal address	PO Box 807 Swakopmund Namibia
Physical address	Schumacher House 6 Tobias Heinyeko Street Swakopmund Namibia
Fax	+264 64 403 327
Phone	+264 64 402 317

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ESIA AMENDMENT PROCESS FOR THE PROPOSED TSUMEB SMELTER UPGRADE AND OPTIMISATION PROJECT: ENVIRONMENTAL IMPACT REPORT

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ACRONYMS AND ABBREVIATIONS

Below is a list of acronyms and abbreviations used in this report:

Acronyms / Abbreviations	Definition
asl	above sea level
DEA	Directorate of Environmental Affairs
DPMT	Dundee Precious Metals Inc. Tsumeb
EAP	Environmental Assessment Practitioner
ECC	Environmental Clearance Certificate
ESIA	Environmental and Social Impact Assessment
EMP	Environmental Management Plan
HDPE	High-density polyethylene
IAPs	Interested and Affected Party
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
MAWF	Ministry of Agriculture, Water and Forestry
MET	Ministry of Environment and Tourism
MHSS	Ministry of Health and Social Services
msl	Mean sea level
NGO	Non-Governmental Organizations
NSRs	Noise sensitive receptors
PM _{2.5}	Inhalable particulate matter with an aerodynamic diameter of less than 2.5 m
PM ₁₀	Thoracic particulate matter with an aerodynamic diameter of less than 10 m
PPP	Public Participation Process
SLR	SLR Environmental Consulting (Namibia) (Pty) Ltd

EXECUTIVE SUMMARY

1. INTRODUCTION TO THE PROPOSED PROJECT

The Tsumeb Smelter is currently owned and operated by Dundee Precious Metals Tsumeb (DPMT), a subsidiary of the Canadian based Dundee Precious Metals (Pty) Ltd. The smelter is located on the outskirts of Tsumeb in the Oshikoto Region of Namibia, approximately 2 km northeast of the Tsumeb town centre. The local setting of the Tsumeb Smelter is shown in Figure 1-1.

The smelter was constructed in the early 1960s to process concentrate from the Tsumeb copper mine and is one of only five commercial-scale smelters in Africa capable of processing concentrates with a high arsenic content. Currently, it receives copper concentrate from El Brocal (Peru), Chelopech (Bulgaria), Codelco (Chile), Armenia and Opuwo (Namibia) for processing in the smelter.

Following the purchase of the smelter complex in 2010, DPMT have undertaken a series of upgrades and improvement projects, including the following:

- Construction of a hazardous waste disposal site (2012);
- Addition of a second oxygen plant (2012);
- Improvement of the off-gas handling systems (2012-2013);
- Closure of the reverberatory furnace (2013);
- Addition of a 1,540 t/d sulphuric acid plant and associated acid storage and dispatch facilities (mid 2015);
- Addition of two new and larger Peirce-Smith converters (end 2015);
- A new effluent treatment plant; and
- Decommissioning of the arsenic plant (end of February 2017).

The Tsumeb Smelter now comprises of one primary smelting furnace, the refurbished Ausmelt furnace. Blister copper is produced from the copper concentrate and delivered to refineries for final processing. Up to recently, a portion of the arsenic contained in the concentrate feed was converted to arsenic trioxide (As_2O_3) through the arsenic plant and sold to third parties. The arsenic plant is currently in the process of being decommissioned and As_2O_3 production has ceased.

With additional custom concentrates available worldwide and areas for operational improvements identified, DPMT is now proposing to expand their current operations in order to increase their concentrate processing capacity from approximately 240 000 to 370 000 tons per annum (tpa). The proposed expansion would be contained within the existing facility footprint and would include the following components:

- Upgrading of the existing Ausmelt feed and furnace;
- Installation of a rotary holding furnace (RHF);
- Implementation of slow cooling of the RHF and converter slag;

- Upgrading of the slag mill to improve copper recovery and handle the increased tonnage from slow cooled slags;
- Option to install an additional Peirce-Smith (PS) converter; and
- Additional related infrastructure improvements (power supply, etc.).

The new project components and associated service infrastructure, together with the existing (approved) infrastructure/facilities, is collectively referred to as the 'Tsumeb Smelter Upgrade and Optimisation Project'.

DPMT currently holds an Environmental Clearance Certificate (ECC) in terms of the Environmental Management Act (No. 7 of 2007; EMA) for its operations at the Tsumeb Smelter. To allow for the proposed Upgrade and Optimisation Project, an amendment of the original Environmental and Social Impact Assessment (ESIA) and Environmental Management Plan (EMP) is required. This report focuses on the above mentioned additional components not covered in the current ECC and EMP.

DPMT currently also holds various other ECCs and EMPs for different project components established after the original ECC for the Smelter operations was issued. The objective of this project and ESIA Amendment process is further to combine all of the commitments in the separate EMPs into one consolidated EMP for all DPMT's facilities and operational components. This is beneficial, as impacts and related management and mitigation measures will be considered cumulatively and it would be easier to manage the environmental aspects if consolidated into one document linked to DPMT's overarching management system. If approval is granted and an Amended ECC issued, it would then serve as a consolidated ECC for the entire DPMT Smelter complex and would supersede the previous ECCs.

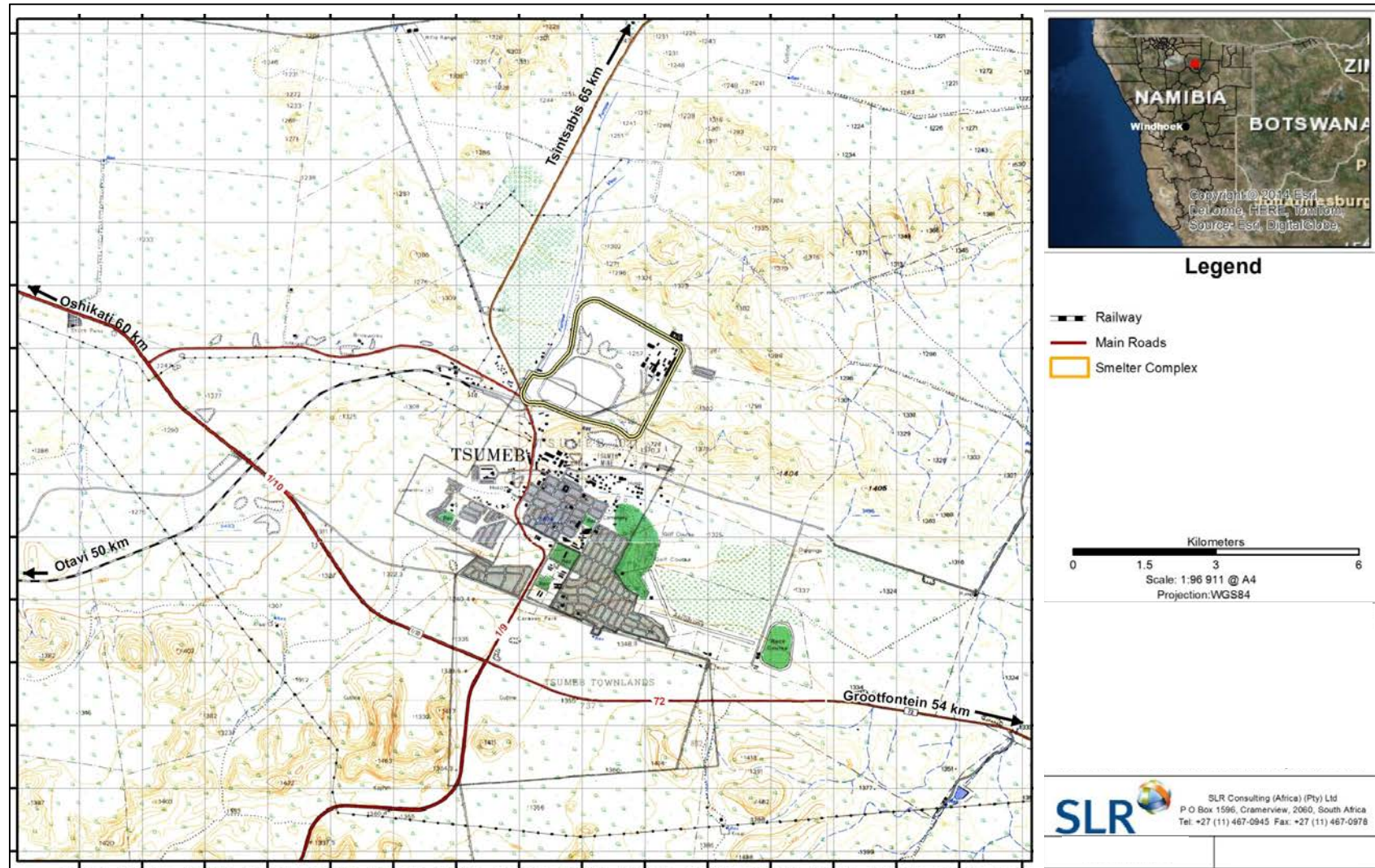


FIGURE 1: LOCAL SETTING OF THE TSUMEB SMELTER COMPLEX

2. PROJECT MOTIVATION

The motivation to support the project is economic in nature, with the project having the potential to directly and indirectly benefit the country and surrounding communities. The project would improve the smelter's competitive position for securing feed materials and enhance the asset's long term viability.

The Tsumeb smelter currently employs between 600 and 700 persons in Tsumeb, with many other services directly dependent on DPMT operations. As the proposed project would largely relate to the optimisation of existing components and processes within the facility, it would not create a high number of new employment opportunities. Some opportunities would, however, be created for contractors during the construction phase. The proposed upgrade and optimisation of the smelter and related increase in the throughput capacity of the smelter would, however, promote long term efficiency and economic sustainability of the facility. By increasing the efficiency and sustainability of the facility, long term employment security would be ensured, together with downstream economic benefits to the town of Tsumeb.

The Tsumeb Smelter is unique in that it has the ability to process high sulphur, high arsenic and low copper grade concentrates. It is one of only five commercial-scale smelters in Africa capable of processing concentrates with a high arsenic content. It thus provides highly specialised services to global clients. Upgrading the smelter capacity to 370 000 tpa would ensure that the facility can operate at a higher efficiency level with the related economic benefits.

The current proposed Upgrading and Optimisation Project is one of the later phases of an overall optimisation and expansion which has already required substantial capital investment. Recovering the cost of this investment would be significantly more challenging should the proposed project not go ahead, putting the future economic viability of the smelter at risk.

In addition, the proposed expansion would increase the amount of foreign revenue generated by DPMT through value addition and provide benefits in a region with relatively high socio-economic needs. It should thus achieve in-principle compatibility with key Namibian economic policies and plans, provided environmental and other impacts can be adequately mitigated.

3. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT PROCESS

Environmental Impact Assessments (EIA) are regulated by the Ministry of Environment and Tourism (MET) in terms of the Environmental Management Act, 7 of 2007. This Act was gazetted on 27 December 2007 (Government Gazette No. 3966) and the EIA Regulations were promulgated on 6 February 2012.

The proposed Upgrade and Optimisation Project requires the amendment of some of the project components previously approved. Section 19 of the above mentioned EIA Regulations allows for an amendment of an ECC under section 39 of the Environmental Management Act, 2007.

Due to the significant potential environmental impacts associated with the general operations of a smelter of this nature and the ongoing public interest in the facility, MET: DEA requested that a full ESIA process

(including a scoping phase and an assessment of impacts phase) be undertaken to assess the new project components. Impacts from the proposed upgraded and new project components would be assessed as cumulative to the impacts experienced from the current Tsumeb Smelter operations.

In accordance with this legal framework the ESIA approach included the following:

- The scoping process was conducted to identify the environmental issues associated with the proposed project and to define the terms of reference for the required specialist studies;
- Specialist studies were commissioned in accordance with the relevant terms of reference;
- The ESIA report was compiled on the basis of the findings of the specialist studies;
- A Consolidated EMP was prepared to elaborate on the mitigation objectives, include additional actions that were described in the ESIA report and consolidate previously approved EMPs; and
- A project specific public participation process was conducted. As part of this process the regulatory authorities and interested and affected parties (IAPs) were given the opportunity to attend information sharing meetings, submit questions and comments to the project team, and review the background information document and scoping report. All questions and comments that were raised by the authorities and IAPs have been included and addressed in the ESIA report. Similarly, IAPs have the opportunity to review the ESIA Report and provide additional comments before it will be finalised. Public feedback meetings have been arranged to present the findings of the ESIA to IAPs.

4. PROJECT OVERVIEW

The current proposed Upgrade and Optimisation Project was selected as the preferred option through a pre-feasibility study process and would increase the concentrate throughput capacity from 240 000 tpa to 370 000 tpa. All new project components would be constructed within the current facility footprint and no greenfield areas would need to be cleared. The proposed expanded operations are illustrated in the process flow diagram in Figure 2. The new and upgraded components required in order to reach the increased throughput capacity include the following:

- Upgrading of the current Ausmelt concentrate and reverts feeders;
- Upgrading of the Ausmelt cooling system to a closed loop cooling water circuit;
- Design improvements to Ausmelt hoods and ladles;
- New RHF with shell dimensions of 4.7 m (diameter) by 15.2 m (long) and 70 m high steel stack;
- The option to install a third 13 x 30 ft Peirce-Smith converter is considered. The addition of a third converter would allow for the other two converters to be online while the third converter could be offline for maintenance;
- Slag slow cooling in pots or pits before crushing by an independent contractor;
- Key changes/additions to the slag mill process include the following:
 - An upgrade of the milling and classification circuits;

- Rationalization of flotation capacity by elimination of oxide rougher bank #2 and oxide cleaner cells;
- Replacement of concentrate vacuum drum filter with a 4-leaf 6ft.(1.83m) diameter disc filter;
- Addition of instrumentation in the grinding and flotation circuits and improved sampling practices to enhance metallurgical control and stability; and
- Organizational changes suggested include measures to reinforce operator training and preventative maintenance to achieve 90% slag mill availability.
- Required utility upgrades include the following:
 - A new instrument air dryer;
 - Increase of the pump capacity for raw water from the old mine shaft;
 - Two additional light fuel oil supply pumps and piping to supply the RHF;
 - Two additional heavy fuel oil supply pumps and two heaters as part of the oil supply ring for the RHF burners;
 - Upgraded electricity supply system to be housed in a new electrical building.
- Increased road transport requirements of an additional two to five truckloads of copper concentrate to Tsumeb from Walvis Bay per day.

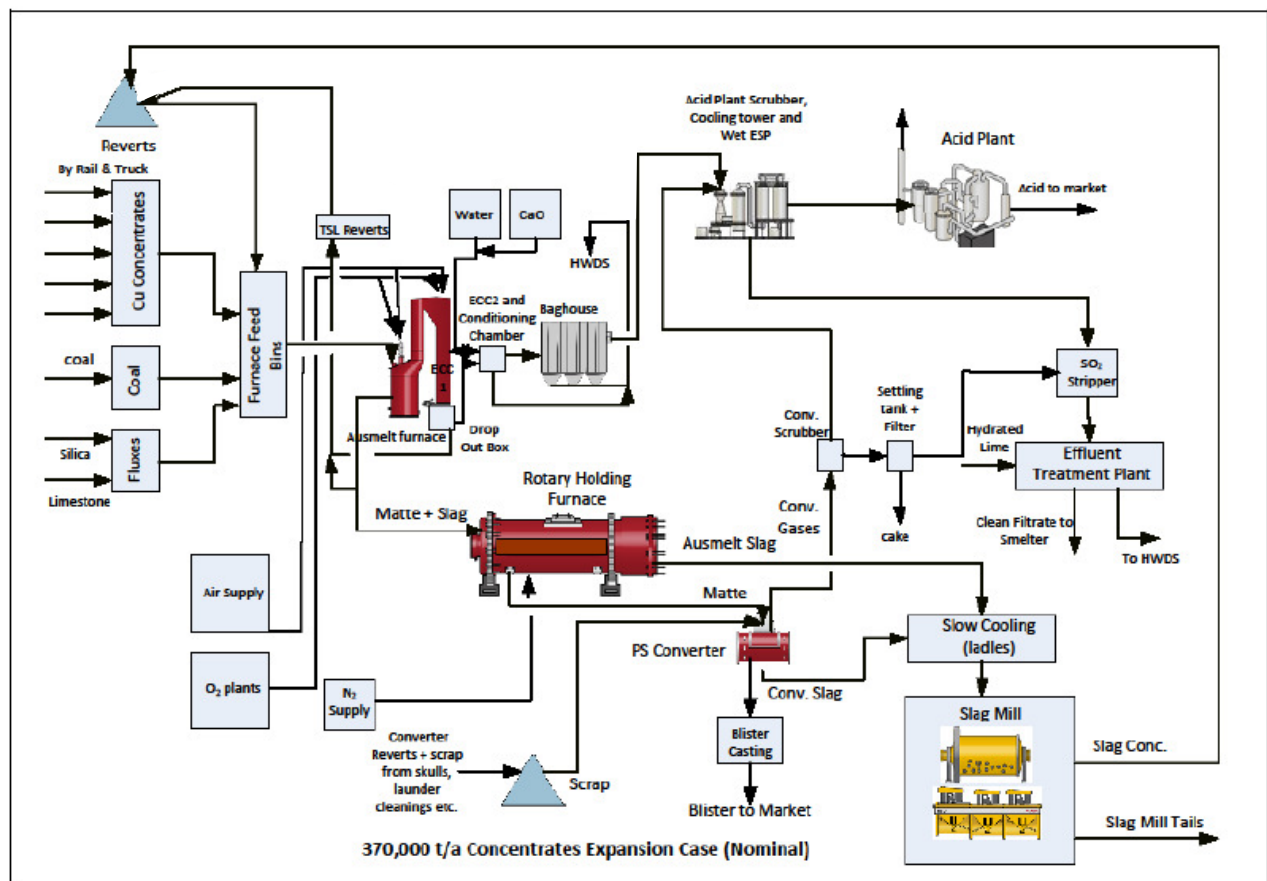


FIGURE 2: PROCESS FLOW DIAGRAM FOR THE EXPANDED TSUMEB SMELTER OPERATIONS. [RED AND YELLOW ITEMS INDICATE THE NEW/UPGRADED COMPONENTS LINKED INTO THE EXISTING PROCESS STEPS] (WORLEYPARSONS, 2015)

5. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FINDINGS

WASTE MANAGEMENT

A review of current waste management activities at the smelter was undertaken and various recommendations made for management improvement. Main findings related to the need for a formalised general waste landfill site or further investigation into the establishment of a waste incinerator and the improvement of waste sorting at the general waste handling area on site. Since the waste management review, DPMT has continued to formalise waste collection points by providing skips for the sorting and collection of different waste items. This is regarded as a positive development in terms of improving general waste management on the smelter site.

The review also included calculations of the remaining life of the on-site hazardous waste disposal site. The findings showed that with the additional arsenic waste volumes to be produced and disposed it is likely that the existing waste cell has a life span of one and a half to two years from February 2017. The entire permitted disposal site has an estimated life span of around 8 years. These calculations were based on the assumption that all arsenic waste would be disposed of at this site and no other options for disposal are considered. DPMT are, however, currently investigating the feasibility of other disposal options. These include disposal to a potential future regional site in Namibia or to transport the wastes to hazardous waste sites in South Africa. DPMT are also currently investigating vitrification of the flue dust which would render it non-hazardous, and saleable, resulting in a reduction in the volume of hazardous waste to be disposed of.

SURFACE WATER

There are no natural surface water sources within the smelter property and the assessment thus relates to stormwater runoff. The proposed expansion would result in additional volumes of slag material being produced, which could require additional areas to be used for disposal of this material. Mitigation measures would thus be required in order to ensure that the stormwater system capacities would be sufficient to handle any additional contact runoff generated. The proposed expansion would not change the current situation with regards to runoff potential, assuming that the stormwater system has not been spilling into the Jordan River system after previous extreme rainfall events. The currently planned improved stormwater management measures include a 'clean' (non-contact) water diversion channel around the northern edge of the main smelter site in order to channel clean runoff away from the smelter site and to the Jordan River. This measure will improve the runoff from the site, as less water will flow into the smelter area and be retained in the 'dirty' (contact) water system at the site. Improved stormwater management measures in line with a stormwater management plan is currently being implemented in phases and include, amongst other measures, the establishment of lined polluted water collection dams. With these measures in place, there should be only a small likelihood of any contact water leaving the site and reaching the Jordan River, approximately 1 km north of the site

Due to there not being any downstream water users between the smelter site and the Jordan River to the west of the site, which has a limited flow for a short distance downstream, and the implementation of improved stormwater management measures, it is expected that the cumulative impact of the proposed expansion project on surface water runoff and quality would be of low significance. Key mitigation measures include the construction of additional infrastructure to manage contact water around the smelter expansion site, if required and the establishment of a surface water monitoring programme at various sites along the Jordan River in order to monitor pollution levels.

GROUNDWATER QUALITY

The geohydrology of the area shows that groundwater flow is in a northerly direction from Tsumeb. Based on measured data for heavy metal and sulphate concentrations, the baseline groundwater quality before the proposed expansion indicates that the smelter site has already impacted significantly on groundwater quality on site. Modelling data showed that polluted groundwater could potentially migrate offsite. Contamination plume modelling from 2013 and 2016 groundwater reports by GCS indicate that arsenic concentrations could potentially become elevated offsite and the plume is likely to continue to move to the north, potentially eventually impacting on irrigation boreholes if no action is taken to prevent this. The accuracy of this model has been brought into question as part of the current assessment and it has been proposed that an updated model be developed, taking Government groundwater studies to the north of Tsumeb into consideration, for more accurate predictions of groundwater flows.

It is not expected that the proposed expansion project would contribute significantly to the current groundwater impacts from historic and current operations. In the unmitigated case, the significance of the impacts currently being experienced is considered as high. In the mitigated case, the significance can be reduced to medium, since the Group B (Namibian drinking water standard) water quality limit could be reached with the implementation of mitigation measures. As the impact is already being experienced, the impact of the proposed expansion on groundwater quality is assessed as cumulative, with the impact largely being attributable to historic activities.

Some of the key mitigation measures include the following (included in expansion project capital and operating costs):

- Refine the current groundwater model in order to make accurate predictions of groundwater flow.
- Complete the study on sources of contamination and potential remedial action (currently only in a planning stage with scope of work developed with the intention of tendering the work out in 2017).
- Investigate targeted solutions for groundwater treatment and pollution source elimination in order to reduce potential offsite pollution. Also consider an increase in the number of recovery boreholes.
- Rehabilitate polluting dumps in line with the closure plan recommendations.
- Dispose of waste material at a suitable disposal site. This would require the establishment of a formal waste site or addition of incinerator for the additional waste volumes to be generated.
- Implement the phytoremediation trials in line with the closure plan.
- Drill additional monitoring boreholes offsite in the downgradient direction and into different geological / hydrogeological environments.

- Include regional groundwater monitoring from existing farm and municipal boreholes and produce a detailed groundwater monitoring schedule.
- Regularly sample monitoring boreholes in order to timeously identify changes in groundwater quality.

AIR QUALITY

There have been notable decreases in air emissions from smelter operations during 2016 which can be ascribed to the commissioning of the sulphuric acid plant and decommissioning of the reverberatory furnace.

Sulphur Dioxide

After commissioning of the sulphuric acid plant in 2015, ambient air quality monitoring stations have reported significant downward trends in sulphur dioxide (SO₂) emissions from October 2015 to September 2016. No limits exist for SO₂ emissions in Namibian environmental legislation. Levels are thus evaluated by DPMT against best practice guidelines of 125 µg/m³ over a 24-hour period. Based on average monthly SO₂ levels, the only exceedance of the annual limit (50 µg/m³) was recorded at the Sewerage Works monitoring station to the west of the smelter site in 2016. Short term assessment criteria (South African 24-hour limit) were, however still exceeded at the monitoring stations in close proximity to the smelter site on a number of occasions during 2016.

It is expected that SO₂ emissions will increase most notably because of the introduction of the RHF where SO₂ will be released during charging and pouring. In order to determine the dispersion of SO₂ from the smelter as a result of the proposed expansion, SO₂ concentrations were simulated at ambient air quality monitoring locations. As the sulphuric acid plant conversion efficiency rate was on average at 76% during 2016, a 76% efficiency rate was used in the simulations. The 76% efficiency rate is considered to be a worst case scenario and it is expected that the acid plant would reach between 90 and 95% efficiency rate on average. The 53% increase in SO₂ emissions from the smelter is expected to result in similar increases in ambient SO₂ concentrations. The simulation results showed that SO₂ concentrations associated with the proposed plant expansion, would exceed the South African 1-year average assessment criterion of 50 µg/m³ at the Sewerage Works station (123 µg/m³) and eastern parts of Tsumeb. The 24-hour average criterion (4 days of exceedance of 125 µg/m³) is exceeded at the Sewerage Works (304 µg/m³) and most of Tsumeb (see Figure 3). The 99th percentile of 1-hour average concentrations (equivalent to the 88th highest hour) exceeds the adopted criterion of 350 µg/m³ (or 88 hours of exceedance of 350 µg/m³) across Tsumeb.

As mentioned above, in 2016 the average conversion efficiency of the sulphuric acid plant was 76%. It was calculated that an efficiency rate of 95% would be required to ensure that ambient SO₂ levels remain within the adopted SO₂ assessment criteria (see Figure 4). Since commissioning of the plant towards the end of 2015, the plant performed at its best in May 2016 when a conversion efficiency of 90% was reached.

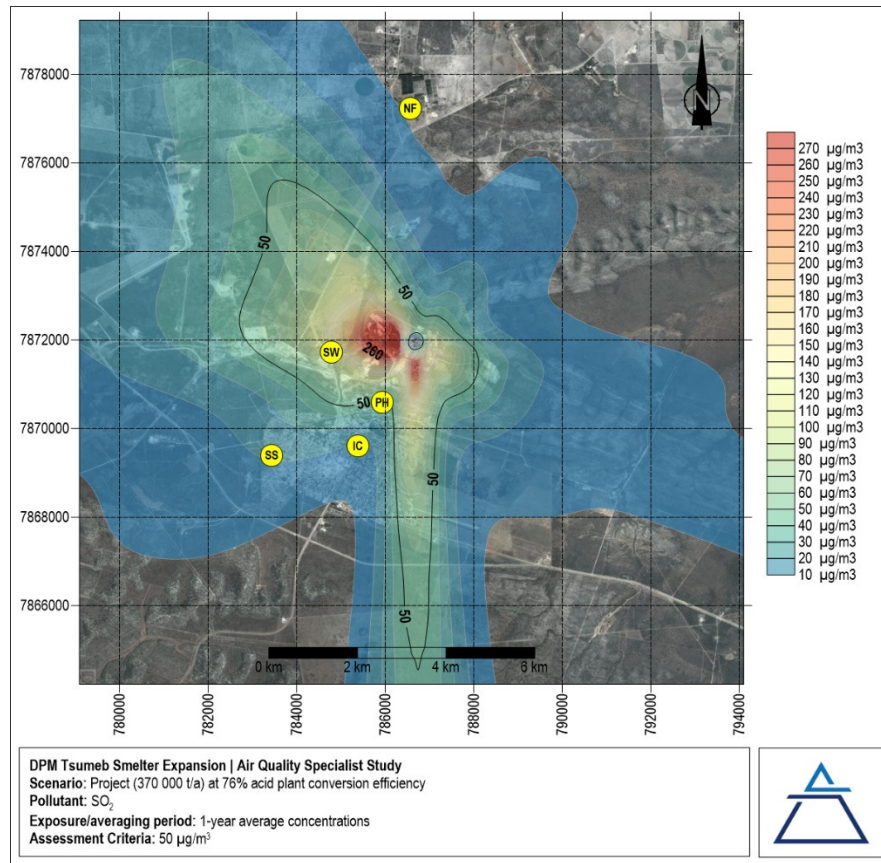


FIGURE 3: SIMULATED 1-YEAR AVERAGE SO₂ CONCENTRATIONS AT 76% ACID PLANT CONVERSION EFFICIENCY

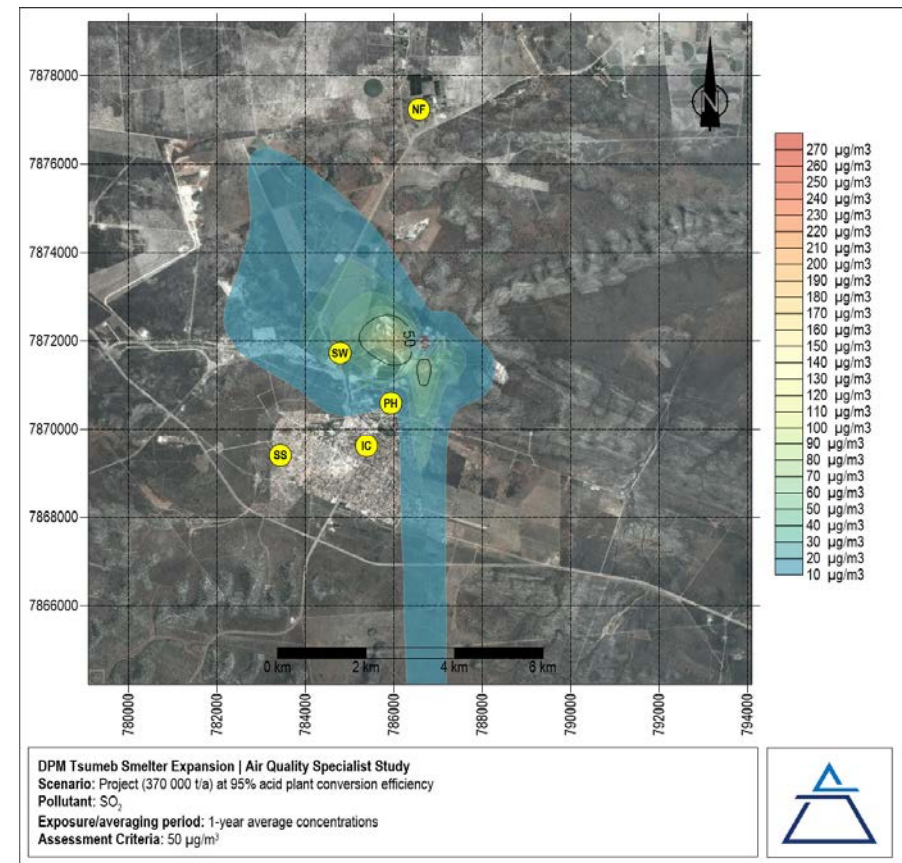


FIGURE 4: SIMULATED 1-YEAR AVERAGE SO₂ CONCENTRATIONS AT 95% ACID PLANT CONVERSION EFFICIENCY

Sulphuric acid

Ambient sulphuric acid (H_2SO_4) levels are expected to increase by a factor of 1.4 due to the proposed increased throughput capacity. Simulations showed that both the annual and 1-hour average off-site concentrations will, however, be well within ambient air quality limits.

PM₁₀

Based on data from ambient air quality monitoring stations in Tsumeb town itself, the main contribution of airborne particulate matter (PM₁₀) sources seem to not be from the smelter site. The monitoring station immediately to the west of the smelter (Sewerage Works station) reflects activities and sources associated with the smelter operations, likely from the tailings facilities. The proposed increased throughput capacity is expected to increase both long and short term ambient PM₁₀ concentrations by a factor of approximately 1.2. Simulated levels associated with the proposed upgrade project do, however, not exceed PM₁₀ air quality limits off-site.

Arsenic

Arsenic in the PM₁₀ fraction is measured at all ambient air quality stations and showed a marked decrease in annual average concentrations from 2013 to 2016 with average concentrations ranging between 0.1 $\mu\text{g}/\text{m}^3$ and 0.3 $\mu\text{g}/\text{m}^3$. These levels are considered to exceed the chronic inhalation reference concentration of 0.015 $\mu\text{g}/\text{m}^3$ outside of the smelter footprint. It was found that furnace building fugitives (fumes escaping primary and secondary capture systems) contribute most notably to these off-site arsenic impacts. The results clearly show higher ambient arsenic levels during dry and windy months. This also indicates fugitive dust rather than stack emissions from the smelter as the cause of elevated arsenic concentrations.

Simulations showed that ground level ambient arsenic levels could potentially increase by approximately 54% due to the proposed increased throughput capacity of the smelter. The increase is attributed to the assumption that furnace building fugitive emissions will increase linearly with increased production rates. The contribution of additional arsenic emissions from the proposed RHF to ground level arsenic concentrations is, however, minimal. Efforts should therefore be made to reduce building fugitive emissions through suitable and effective engineering controls.

Applying the WHO unit risk factor of 0.0015 $\mu\text{g}/\text{m}^3$ to the annual average concentrations, the increased lifetime cancer risk in Tsumeb was rated as low for the current and increased throughput capacity and as moderate on the smelter boundary. The level at the smelter boundary is considered to be at the upper level of what might be considered acceptable, from a non-carcinogenic and carcinogenic inhalation health exposure perspective. This result, however, assumes that arsenic in air might be the main exposure pathway for Tsumeb residents. This matter was investigated further by a community health specialist and is further assessed in the community health impact section later in this executive summary.

Based on the above findings for all the emissions considered, the overall significance of exceedances of ambient air quality standards in Tsumeb due to the proposed increased throughput capacity of the smelter is considered to be medium without mitigation given 2016 performance levels of the sulphuric acid plant and fugitive emissions management systems. With mitigation, the impact significance may be reduced to low-medium. Key mitigation measures include efficient capture of fugitive dust emissions across the smelter site, improving the sulphuric acid plant conversion efficiency to 95% and undertake continuous monitoring of SO₂ emissions through the acid plant stack in order to provide a true reflection of SO₂ emissions over time and an accurate dispersion plume.

NOISE

The noise assessment found that the only noise sensitive receptors where where activities from the smelter complex were audible was the farmstead on the property of Mr Danie Potgieter, approximately 650 m northwest of the smelter boundary and 600 m east of the M75 road. It was found that noise levels in the town are greatly affected by community activities and highly dependent on wind speed. Noise simulations indicated that the proposed increased throughput capacity would not result in exceedances of noise levels guidelines at noise sensitive receptors. The increases in noise levels above the measured background level of 44.8 dBA during the day and 39.4 during the night were found to be less than 3 dBA at all noise sensitive receptor and thus not detectable. The potential noise impacts were thus rated as of low significance. Key mitigation measures included improvement of the silencer at the No. 2 oxygen plant and establishing a noise monitoring programme at noise sensitive receptors.

SOCIO-ECONOMIC

Construction phase project expenditure (positive impact)

The construction phase of the project would result in spending injections that would lead to increased economic activity. All expenditures will lead to linked direct, indirect and induced impacts on employment and incomes. In the case of employment, impacts would be direct where people are employed directly for the construction of new project components (e.g. jobs such as construction workers). Indirect impacts would be where the direct expenditure associated with the project leads to jobs and incomes in other sectors (e.g. purchasing building materials maintains jobs in that sector) and induced impacts where jobs are created due to the expenditure of employees and other consumers that gained from the project. Preliminary estimates indicate that a total of around N\$722 million would be spent on all aspects of construction over the roughly one and a half year construction period and that approximately 185 person years of temporary employment would be created. Approximately N\$155.8 million would be spent on suppliers in the local Tsumeb municipal area. The overall construction phase expenditure is assessed to be of low-medium positive significance. It is recommended that local labour and sub-contractors be utilised as far as possible and that opportunities for the training of unskilled and skilled workers from local communities be maximised.

Operational phase expenditure and increase in corporate social responsibility spending (positive impact)

It is not expected that new direct employment opportunities would be created at the smelter during the operational phase, but rather that existing employees would be redeployed within the facility. Economic benefits during the operational phase largely relate to indirect employment opportunities for service providers (e.g. electricity, transport and handling services, engineering services and local municipal services). It is expected that these benefits would be experienced on a local to national scale and is considered to be of medium positive significance.

It is also expected that there may be an increase in DPMT's corporate social responsibility spending with the increased revenue to be generated by the upgrade project. This potential benefit is rated as of medium positive significance. When assessed as cumulative to current contributions, the significance is increased to high positive, given the already significant contributions being made.

Macro-economic Benefits (positive impact)

In terms of macro-economic benefits, it is expected that foreign exchange earnings resulting from the proposed expansion would average around US\$66 million per year for copper blister and sulphuric acid exports. These would be in addition to current earnings of approximately US\$140 million per year. This increase is likely to have a strong positive impact on the Namibian economy and the macro-economic benefit is thus rated as of medium to high positive significance. In this regard, it is recommended that DPMT favour Namibian suppliers of goods and services, where possible.

Negative impact of construction workers on local communities

The presence of construction workers from outside the local area could have the potential to impact on local communities by disrupting existing family structures and social networks through their conduct. Risks include, e.g. an increase in alcohol and drug use and related crime levels. Due to the rapid increase in the population of Tsumeb in the last five years and the high numbers of truck drivers and other road users passing through the town on a monthly basis, the presence of additional workers from outside the area over a one and a half year construction period is unlikely to have a significant impact on the local community. While these impacts may be considered unlikely at a community level, at an individual and family level they may be more significant, especially in the case of contracting a sexually transmitted disease or having an unplanned pregnancy. The overall impact is considered as of low negative significance after the implementation of mitigation measures. Recommended measures include the appointment of local labour as far as possible and the briefing of local communities on the potential risks associated with construction workers.

Negative impact of smelter decommissioning and closure

Given the relatively high number of permanent employees (667) the potential impacts associated with potential future decommissioning and closure of the smelter would be significant. The major social impacts associated with the decommissioning phase are linked to the loss of jobs and associated

income. This has implications for the households who are directly affected, the communities within which they live, and the relevant local authorities. In the absence of an effective plan to manage the social and economic impacts associated with smelter closure and decommissioning, the impacts will be significant. However, the potential impacts associated with the decommissioning phase can be effectively managed with the implementation of an effective and well planned retrenchment and downscaling programme. With these plans in place, the negative impacts associated with the potential future decommissioning and closure of the smelter could be reduced to of low negative significance. Recommendations in this regard include appropriate retrenchment packages, the implementation of skills training programmes and ensuring that DPMT's Asset Retirement Obligations are accurate and current in order to fund its Closure Plan objectives. The current proposed project would extend the viability of the smelter and thus defer the ultimate negative impacts related to decommissioning and closure.

COMMUNITY HEALTH

Impacts related to SO₂ and PM₁₀ exposure

Although a marked decrease in SO₂ emissions has been experienced after the installation of the sulphuric acid plant and other capital improvements at the smelter, exceedance of the South African and WHO 24-hour limits was still recorded on a monthly basis outside of the smelter boundary during 2016. Exceedances of the SA NAAQS standards (125 µg/m³) were recorded at the monitoring stations closest to the smelter (i.e. Plant Hill and Sewage Works), but not at the monitoring stations within Tsumeb (i.e. Info Centre and Sport Stadium). When considering the long-term effects of SO₂ exposure, findings of previous studies (Linn *et al.*, 1987) found that there was no irreversible adverse respiratory impact as measured by lung function on asthmatics and atopic individuals under conditions of exposure at least an order of magnitude higher than levels experienced in the Tsumeb area. These findings were also confirmed by the results of the respiratory health questionnaires completed by Tsumeb residents as part of the community health assessment. Elevated SO₂ concentrations, however, have an irritant effect on the respiratory system, causing a symptom burden for the receptor population, especially for those with asthma-related symptoms. While the level of exposure is not likely to cause a substantial symptom burden or irreversible effects, there is definitely a nuisance burden experienced by Tsumeb residents.

It was noted in the specialist assessment that capital improvements were not yet fully implemented during 2016 when the study was undertaken and that it can be assumed that when these improvements function optimally, it would result in further reduction in SO₂ exposures going forward. Improved ventilation extraction from new converts and new methods of slag cooling may be expected to bring about further future reductions in exposure. With the sulphuric acid plant functioning at its optimal design capacity, the appropriate use of hoods at the RHF and improved ventilation extraction, increasingly more efficient capture of SO₂ would be likely, notwithstanding any increase in the production throughput.

The current burden of disease caused by PM₁₀ for Tsumeb residents is considered to be small. Simulation results of the air quality assessment showed that it is not expected that increased PM₁₀ emissions as a result of the expanded smelter operations would cause an exceedance of daily PM₁₀

WHO interim targets (i.e. $75 \mu\text{g}/\text{m}^3$) or stricter WHO first world targets (i.e. $50 \mu\text{g}/\text{m}^3$) outside of the smelter footprint. It is thus not expected that the proposed project would add cumulatively to the current burden of disease experienced from PM_{10} sources.

Based on the above, the potential community health impacts largely relate to the upper and lower respiratory symptoms attributable to SO_2 exposures experienced in all areas of Tsumeb. The impact is assessed as cumulative to the current effects experienced by Tsumeb residents and rated as of low significance after mitigation. In addition to achieving optimum sulphuric acid plant conversion efficiency, the key mitigation measure is the implementation of engineering solutions to better control fugitive emissions at all components of the smelter operations.

Arsenic exposures

The community health assessment included analysis of urine arsenic levels in community members from different residential areas in Tsumeb, compared with an unexposed control group in Oshakati. When considering the latest emissions data together with results of the urine arsenic levels, elevated urine arsenic levels were found in Tsumeb when compared to the unexposed control samples in Oshakati. The main findings of the community health investigation, however, showed that there did not seem to be a general systemic overexposure problem based on urine inorganic (attributable to mining/smelter operations) arsenic for Tsumeb residents as a whole. The geometric mean was actually found to be below the most conservative international occupational hygiene standard of $35 \mu\text{g}/\text{l}$ (American Conference for Governmental Industrial Hygienists -ACGIH). The overall impacts on Tsumeb communities were thus estimated to be negligible. Further detailed investigations were recommended for the Town North community (particularly Ondundu), where mean levels were higher, and showed a high proportion (18.9%) of outliers above the Namibian Biological Exposure Index for inorganic arsenic of $50 \mu\text{g}/\text{l}$. As the results of the investigation showed that arsenic in airborne PM_{10} and in drinking water could not be responsible for the elevated urine arsenic levels in outlier samples from Ondundu, attention must be directed to arsenic in dust from roadways and garden soil, arsenic in vegetables and fruit grown locally in Ondundu, and hand to mouth behaviour by both children and adults resulting in arsenic ingestion.

From the available data, the risk of lung cancer due to environmental arsenic exposure is low for Tsumeb overall. There is no risk above baseline occurrence of cancer for Tsumeb suburbs, with the exception of the northern town area (principally Ondundu) where the risk is considered to be low (further details regarding the calculations of cancer risk factors are provided in Section 13.2 of the community health assessment in Appendix I).

Based on regression analysis, no significant increase in airborne arsenic exposures for residents is expected at the proposed increased throughput capacity. Alternative options for hazardous arsenic waste disposal are currently being investigated by DPMT, with investigations at an advanced stage. This will lead to the eventual closure and capping of the hazardous waste site when the approved capacity is

reached, which would likely result in a further reduction in environmental arsenic exposures to both the smelter employees and Tsumeb residents, particularly the closest residential areas at Ondundu. It was noted in the specialist assessment that capital improvements were not yet fully implemented during 2016 and that it can be assumed that when these improvements function optimally, it would result in further reduced arsenic exposures going forward.

While the shutdown of the arsenic plant, one of the most antiquated components at the facility, during the first quarter of 2017 will result in a reduction in arsenic exposure for employees at the plant, it would also result in an increase (up to 25%) in the volumes of arsenic waste to be disposed of at the hazardous waste disposal site. If not well managed, windblown arsenic-containing dust (albeit of a less concentrated form of arsenic) from the waste site could contribute to an increase in arsenic exposures which could potentially increase proportionally with an increase in the throughput capacity, as a worst case scenario. Appropriate dust suppression measures are thus critical for arsenic containment. Given the presumptive predominance of the air exposure pathway in determining the impact of the soil exposure pathway on absorbed arsenic as measured in urine arsenic, the latter should decline with the closure of the arsenic plant, further engineering improvements for the management of fugitive dust emissions at the smelter and the eventual closure of the hazardous waste disposal site once the approved capacity is reached. Based on the above, the significance of the impact for Tsumeb as a whole is rated low (overall town area) to medium (Ondundu area closest to the smelter) before mitigation and low for both areas after mitigation. In addition to the closure of the arsenic plant (during first quarter of 2017) and improved control of all fugitive emissions, recommendations were made for further community health investigations. The investigations are to focus on determining arsenic levels in soil and vegetables/fruit and the effect of hand to mouth behaviours, along with further comparing Ondundu and control areas within and outside of Tsumeb. Should soil and home grown food arsenic levels be high, initial prohibition of growing home crops and removal of the topsoil layer should be considered. These additional investigations should inform further actions, which may include an exclusion zone being negotiated around the smelter.

Arsenic exposure to DPMT employees

The assessment of occupational health impacts do not as a rule form part of an ESIA process as occupational health is not dealt with in terms of environmental legislation. As concerns were, however, raised by unions and other I&APs during the scoping phase, occupational health concerns were also addressed as part of the community health assessment. This study component included a review of the use of personal protective equipment (PPE) by employees and assessed the likelihood of an increased cancer risk to employees from the proposed increased throughput capacity. The results of the study showed that PPE and some engineering controls do not seem to be working and there is thus an appreciable occupational lung cancer risk on average for the plant as a whole; more in some business units than in others, depending upon the average air concentration in those units. The corresponding risks are considered to be 2 to 3 times the expected background risk for lung cancer at the current levels of exposure and are thus deemed as a low to medium risk. Modelling results showed that there is little

likelihood of increased exposure (increased urine arsenic levels) going forward. As the capital improvements are completed in the near future, and point of emissions are better controlled, the arsenic plant is shut down and the hazardous waste disposal site is eventually closed and covered after the approved capacity is reached, urinary arsenic levels will decline further. Based on the above, the occupational health impact from increased cancer risk due to arsenic exposure is assessed as of low to medium significance after mitigation. In addition to the closure of the arsenic plant, the key recommended mitigation measures include improved control of fugitive emissions, strengthening the industrial hygiene programme, reducing arsenic exposure pathways, continuing to implement job rotations (but at lower arsenic cut-off values) and improving safe work practices.

6. ENVIRONMENTAL IMPACT STATEMENT AND CONCLUSIONS

A tabulated summary of the potential impacts is presented in Table 1 below. As can be seen from the table below, the impacts associated with the project vary from high positive to high negative without mitigation.

It is possible to mitigate the potential negative impacts by committing to apply the findings of the assessment and related mitigation objectives and actions as presented in the EMP. One of the potential negative impacts will remain of medium negative residual significance even with mitigation. This negative impact relates to the impact of the smelter operations on groundwater quality on and potentially beyond the site boundary. It is important to note that current groundwater quality impacts are related to historic impacts of mining and processing activities on the site prior to the establishment of DPMT's current smelter operations. It is not expected that the proposed expansion project would lead to any measurable cumulative contribution to current groundwater quality impacts. The residual medium cumulative impact rating can thus be ascribed to the baseline groundwater quality conditions and not to the proposed expansion project. It was, however, noted that the current groundwater model would need to be updated in order to provide a more accurate prediction of the likelihood of contaminated groundwater migrating beyond the smelter boundary and build on already recommended mitigation measures for further reducing the significance of impacts on groundwater quality in the vicinity of the smelter complex.

With regards to the potential benefits of the proposed expansion project, the positive cumulative impacts related to socio-economic aspects (i.e. direct construction and operational project expenditure, indirect business opportunities, CSR contributions and macro-economic benefits) were all rated as of high significance after mitigation.

It must be noted that there are currently significant contamination levels on the smelter property and surrounds due to historic mining and smelter operations and legacy waste stockpiles. Although it is acknowledged that the current DPMT smelter operations, since DPMT purchased the facility in 2010, have contributed to and continue to contribute to the overall contamination load, the majority of the measured contamination levels and related impacts (i.e. groundwater and to some extent community

health) are attributable to historic operations. The ongoing Contaminated Land Assessment will aim to quantify the historic and current contributions.

Based on the findings of this ESIA, it is not expected that the proposed increased throughput capacity of the DPMT smelter would have a significant contribution to current negative operational impacts. With the implementation of the proposed mitigation measures and further optimising of the already implemented engineering solutions for the management of air emissions, it is expected that cumulative negative impacts related to smelter operations would be reduced to acceptably lower levels.

The following key aspects with regards to current and future operations are to be addressed as a matter of priority by DPMT:

- Ensure that the sulphuric acid plant and other recent engineering interventions (e.g. hoods) are operating at optimal design levels in order to control SO₂ and other fugitive dust emissions;
- Disposal of general waste by implementing one of the following options:
 - Establishment of a general landfill site within the smelter footprint;
 - Development of a small waste incinerator (would require an additional EIA process); or
 - Disposal at a formalized/licensed municipal landfill site (additional municipal application process would be required).
- A final solution for the disposal of hazardous waste well in advance of the onsite hazardous waste disposal site reaching its full design capacity. The following alternatives should be further considered and a final decision made as soon as possible:
 - Disposal to a potential future regional site in Namibia;
 - Transport of waste to a suitable hazardous waste site in South Africa;
 - Vitrification of flue dust which would render arsenic wastes non-hazardous and saleable; or
 - A combination of the above options.

SLR is of the opinion that the proposed expansion project may be approved, on the condition that the above key aspects are addressed by DPMT as a priority.

TABLE 0-1: SUMMARY OF POTENTIAL IMPACTS ASSOCIATED WITH THE PROPOSED PROJECT

Section	Potential impact	Significance of the impact (the ratings are negative unless otherwise specified)	
		Unmitigated	Mitigated
Surface water	Changes in surface water runoff	L	L
	Surface water pollution	M	L
Groundwater	Groundwater quantity	M	L
	Groundwater quality	H	M
Air quality	Cumulative air pollution impacts	M	L-M
Noise	Cumulative noise pollution impacts	L	L

Section	Potential impact	Significance of the impact (the ratings are negative unless otherwise specified)	
		Unmitigated	Mitigated
Socio-economic impacts	Construction phase project expenditure, including employment and downstream business opportunities	L-M ⁺	L-M ⁺
	Employment phase project expenditure, mainly related to indirect employment opportunities	L-M ⁺	M ⁺ H ⁺ (cumulative)
	Increased Corporate Social Responsibility expenditure	L-M ⁺	M ⁺ H ⁺ (cumulative)
	Macro-economic benefits	M-H ⁺	M-H ⁺ H ⁺ (cumulative)
	Impact of construction workers on local communities	M	L
	Smelter decommissioning and closure	M	L
Community health impacts	Community health impacts related to SO ₂ and PM ₁₀ exposure	M	L
	Community health impacts of arsenic exposures to Tsumeb communities	L-M	L
	Health impacts of arsenic exposures to DPMT employees	H	L

ESIA AMENDMENT PROCESS FOR THE PROPOSED TSUMEB SMELTER UPGRADE AND OPTIMISATION PROJECT: ENVIRONMENTAL IMPACT ASSESSMENT REPORT

1 INTRODUCTION

1.1 INTRODUCTION TO THE PROPOSED PROJECT

The Tsumeb Smelter is currently owned and operated by Dundee Precious Metals Tsumeb (DPMT), a subsidiary of the Canadian based Dundee Precious Metals (Pty) Ltd. The smelter is located on the outskirts of Tsumeb in the Oshikoto Region of Namibia, approximately 2 km northeast of the Tsumeb town centre. The regional and local settings of the Tsumeb Smelter are shown in Figure 1-1 and 1-2.

With additional custom concentrates available worldwide and areas for operational improvements identified, DPMT is now proposing to expand their current operations in order to increase their concentrate processing capacity from approximately 240 000 to 370 000 tons per annum (tpa). The proposed expansion would be contained within the existing facility footprint and would include the following components:

- Upgrading of the existing Ausmelt feed and furnace;
- Installation of a rotary holding furnace (RHF);
- Implementation of slow cooling of the RHF and converter slag;
- Upgrading of the slag mill to improve copper recovery and handle the increased tonnage from slow cooled slags;
- Option to install an additional Peirce-Smith (PS) converter; and
- Additional related infrastructure improvements (power supply, etc.).

The new project components and associated service infrastructure, together with the existing (approved) infrastructure/facilities, is collectively referred to as the 'Tsumeb Smelter Upgrade and Optimisation Project'.

DPMT currently holds an Environmental Clearance Certificate (ECC) in terms of the Environmental Management Act (No. 7 of 2007; EMA) for its operations at the Tsumeb Smelter. To allow for the proposed Upgrade and Optimisation Project, an amendment of the original Environmental and Social Impact Assessment (ESIA) and Environmental Management Plan (EMP) is required. This report focuses on the above mentioned additional components not covered in the current ECC and EMP.

DPMT currently also holds various other ECCs and EMPs for different project components established after the original ECC for the Smelter operations was issued. The objective of this project and ESIA Amendment process is further to combine all of the commitments in the separate EMPs into one consolidated EMP for all DPMT's facilities and operational components. This is beneficial, as impacts and related management and mitigation measures will be considered cumulatively and it would be easier to manage the environmental aspects if consolidated into one document linked to DPMT's overarching

management system. If approval is granted and an Amended ECC issued, it would then serve as a consolidated ECC for the entire DPMT Smelter complex and would supersede the previous ECCs. Refer to Section 1.3.1 for further information relating to previously issued ECCs.

1.2 PROJECT MOTIVATION (NEED AND DESIRABILITY)

1.2.1 ECONOMIC

The motivation to support the project is economic in nature, with the project having the potential to directly and indirectly benefit the country and surrounding communities.

The Tsumeb smelter currently employs between 600 and 700 persons in Tsumeb, with many other services directly dependent on DPMT operations. As the proposed project would largely relate to the optimisation of existing components and processes within the facility, it would not create a high number of new employment opportunities. Some opportunities would, however, be created for contractors during the construction phase. The proposed upgrade and optimisation of the smelter and related increase in the throughput capacity of the smelter would, however, promote long term efficiency and economic sustainability of the facility. By increasing the efficiency and sustainability of the facility, long term employment security would be ensured, together with downstream economic benefits to the town of Tsumeb.

The Tsumeb Smelter is unique in that it has the ability to process high sulphur, high arsenic and low copper grade concentrates. It is one of only five commercial-scale smelters in Africa capable of processing concentrates with a high arsenic content. It thus provides highly specialised services to global clients. Upgrading the smelter capacity to 370 000 tpa would ensure that the facility can operate at a higher efficiency level with the related economic benefits.

An essential aspect of the upgrade is the installation of a RHF, which would make it possible to increase the throughput of the existing Ausmelt furnace. Much of the smelter upgrades that have been implemented since 2012 have enabled the plant to accommodate a concentrate throughput of at least 370 000 tpa, but the Ausmelt production rate cannot be increased without the addition of the holding furnace. The current low utilisation is costly in terms of fixed costs and depreciation of equipment, (such as the acid plant, oxygen plant, converters, etc.) which incurred high costs over the past three years. This, however, presents a unique opportunity for the company to leverage previously invested capital and to achieve higher throughput by alleviating bottlenecks with limited additional expenditure, thereby increasing the profitability and ensuring the sustainability of the operations. In addition, the RHF would facilitate higher production rates, improved recoveries and the reduction in metal lock-up due to reverts (e.g. circulating load in furnace), resulting in a reduction in pollution (reduction of metal in slag and reduction of reverts). By ensuring sustainability and increasing the profitability of the operations, current jobs at the smelter and additional jobs related to the expansion would be preserved and the continued prosperity of Tsumeb would be bolstered.

The current proposed Upgrading and Optimisation Project is one of the later phases of an overall optimisation and expansion which has already required substantial capital investment. Recovering the cost of this investment would be significantly more challenging should the proposed project not go ahead.

1.2.2 COMPATIBILITY WITH KEY POLICY AND PLANNING GUIDANCE

A critical aspect of economic desirability of the proposed project is the compatibility of the project with key Namibian policy and planning guidance. A comprehensive review of compatibility with socio-economic policy and planning was undertaken as part of this ESIA (see Appendix H2). The review includes a consideration of the following documents:

- Vision 2030;
- The Fourth National Development Plan (NDP4);
- Namibia's Industrial Policy; and
- The Logistics Master Plan for Namibia.

The overall conclusion from the review is that the proposed DPMT expansion would be largely compatible with key economic policies and plans, provided environmental and other impacts can be adequately mitigated.

Note also that the Ministry of Trade and Industry (MTI) produced an execution strategy for industrialisation in 2015 called Growth at Home (MTI, 2015). Growth at Home identifies six sectors that show promise in terms of their potential to deliver economic growth and job creation:

- Agro-processing;
- Fish-processing;
- Steel manufacturing and metal fabrication;
- Automotive industry;
- Chemical industry; and
- Jewelry industry.

Overall, the Strategy emphasises the importance of beneficiation as a means to stimulate economic activity. Industrial policy is thus focused on encouraging greater industrial activity and local value addition. Emphasis is also placed on encouraging such activity in areas where other opportunities are limited and socio-economic needs are greatest (MTI, 2015). The proposed expansion would increase the amount of foreign revenue generated by DPMT through value addition and provide benefits in a region with relatively high socio-economic needs. It should thus achieve in-principle compatibility with the Strategy.

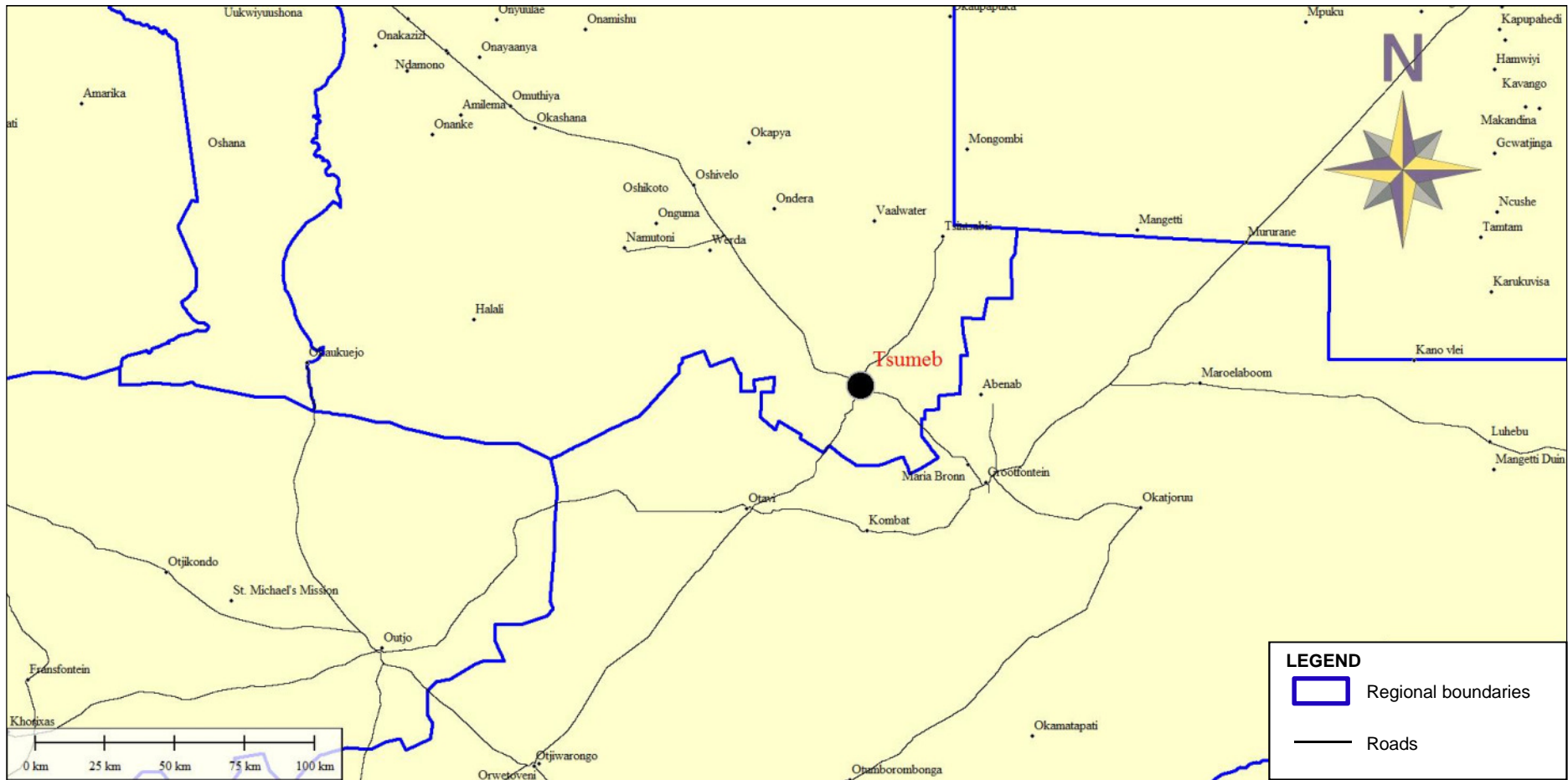


FIGURE 1-1: REGIONAL SETTING OF THE TSUMEB SMELTER

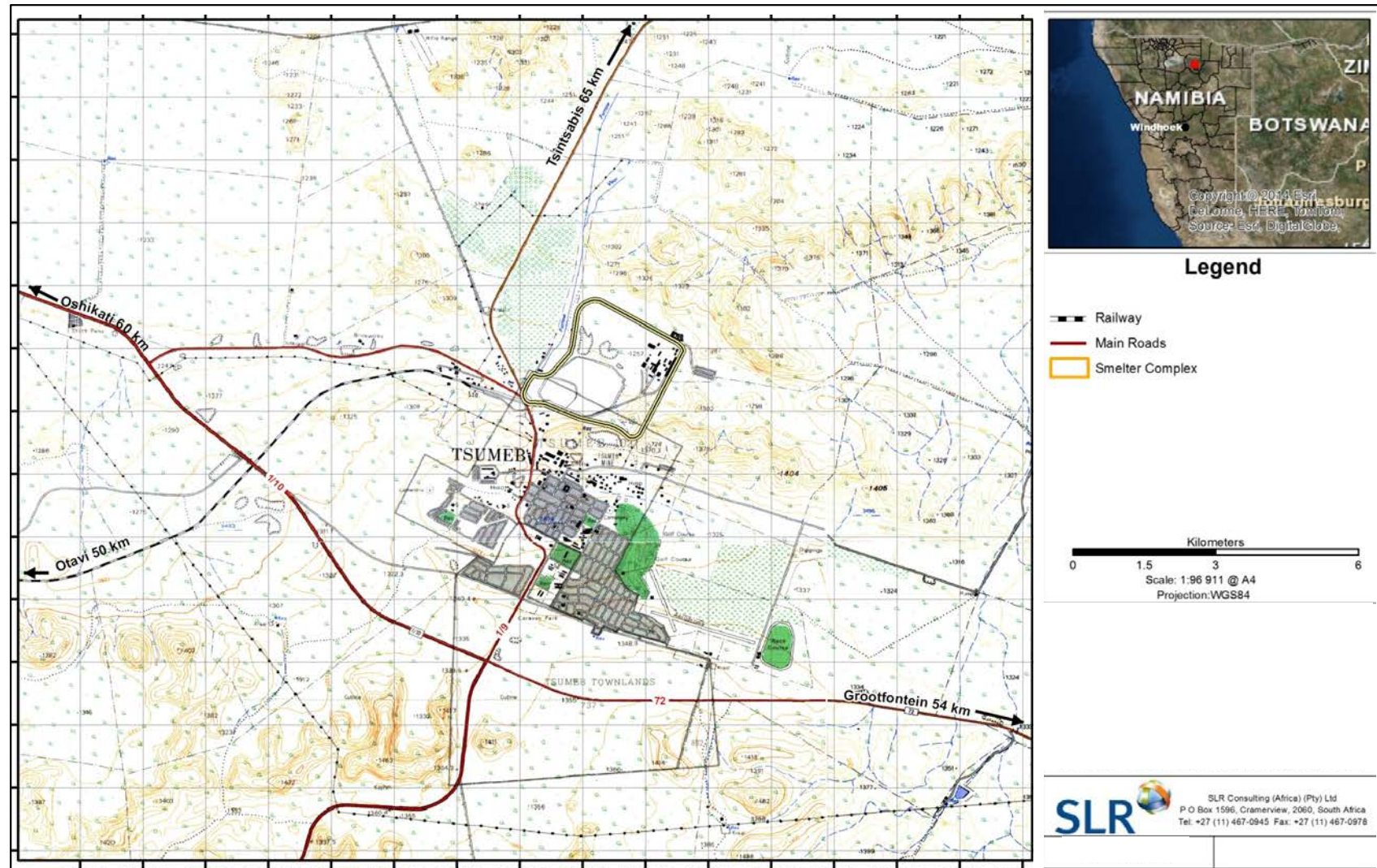


FIGURE 1-2: LOCAL SETTING OF THE TSUMEB SMELTER

1.3 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT PROCESS

Environmental Impact Assessments (EIA) are regulated by the Ministry of Environment and Tourism (MET) in terms of the Environmental Management Act, 7 of 2007. This Act was gazetted on 27 December 2007 (Government Gazette No. 3966) and the EIA Regulations were promulgated on 6 February 2012.

The above mentioned regulations promulgated in terms of the Environmental Management Act, identify certain activities which could have a substantially detrimental effect on the environment. These listed activities require environmental clearance from MET (Department of Environmental Affairs; DEA) prior to commencing. Note that DPMT already holds an ECC for the activities related to the Smelter operations (see Appendix A) as well as various other relevant ECCs (refer to Section 1.3.1). No new listed activities would be triggered by the proposed new project components (i.e. amendments).

The proposed Upgrade and Optimisation Project requires the amendment of some of the project components previously approved. Section 19 of the above mentioned EIA Regulations allows for an amendment of an ECC under section 39 of the Environmental Management Act, 2007.

Due to the significant potential environmental impacts associated with the general operations of a smelter of this nature and the ongoing public interest in the facility, MET: DEA (pers. comm. Mr Damian Nchindo) requested that a full ESIA process (including a scoping phase and an assessment of impacts phase) be undertaken to assess the new project components, even though no new listed activities would be triggered. Impacts from the proposed upgraded and new project components would be assessed as cumulative to the impacts experienced from the current Tsumeb Smelter operations.

As requested by DPMT, the current ESIA process has taken Process Requirements (PR) of the European Bank for Reconstruction and Development (EBRD) into consideration in the compilation of this report and structuring of the public participation process. The EBRD PRs provide a solid base for a company to improve the sustainability of its business operations and to ensure that it operates in compliance with good international practices relating to sustainable development (www.ebrd.com). PR 1 relates to the Assessment and Management of Environmental and Social Impacts and Issues. This PR establishes the importance of integrated assessment in order to identify the environmental and social impacts and issues associated with projects and the client's management of environmental and social performance through the lifecycle of the project (PR 1 - EBRD, 2014). This PR as well as the rest of the ten PR documents were considered by SLR and the relevant independent specialists in undertaking their assessments.

The ESIA amendment process and corresponding activities which will be undertaken for this project are outlined in Table 1-1 below. The process being followed is in accordance with the requirements outlined in the EIA Regulations.

TABLE 1-1: ESIA AMENDMENT PROCESS

Objectives	Corresponding activities
Project initiation and Screening phase (February – March 2016)	
<ul style="list-style-type: none"> Understanding of the environmental and social baseline relating to the proposed smelter upgrade and optimisation project Initiate the screening process Initiate the environmental impact assessment process. 	<ul style="list-style-type: none"> Initiate baseline studies Early identification of environmental aspects and potential impacts associated with the proposed project.
Scoping phase (March – June 2016)	
<ul style="list-style-type: none"> Notify the decision making authority of the proposed project Identify interested and/or affected parties (IAPs) and involve them in the scoping process through information sharing. Identify potential environmental issues associated with the proposed amendment. Consider alternatives. Identify any fatal flaws. Determine the terms of reference for additional assessment work. 	<ul style="list-style-type: none"> Application submitted to MET. Notify government authorities and IAPs of the project and EIA process (telephone calls, e-mails, newspaper and radio advertisements and site notices). Scoping meetings with local authorities and IAPs. Compilation of draft scoping report. Distribute scoping report to relevant authorities and IAPs for review (May 2016). Finalisation of scoping report Forward final scoping report and IAPs comments to MET for review in June 2016. MET accepted the final scoping report on 4 August 2016.
ESIA/EMP phase (June – April 2017)	
<ul style="list-style-type: none"> Provide a detailed description of the potentially affected environment. Assessment of potential environmental impacts. Design requirements and management and mitigation measures. Review of ESIA by MET 	<ul style="list-style-type: none"> Investigations by technical project team and appointed specialists. Compilation of draft ESIA and EMP report. Distribute draft ESIA and EMP report to authorities and IAPs for review. Feedback meetings/open days with local authorities and IAPs Forward the final draft ESIA and EMP report and IAPs comments to MET for review.

Within this framework, the required components of the ESIA report are discussed in more detail as part of the assessment approach in Section 2.

1.3.1 EIAs COMPLETED AND APPROVED

A number of EIAs have been undertaken for DPMT's current operations. These are set out in Table 1-2 below:

TABLE 1-2: PREVIOUS DPMT EIA PROCESSES AND APPROVALS

Year	Description
2011	After purchasing the Namibia Custom Smelters in 2010, DPMT commissioned an EIA in order to determine the effect that the operation of the Tsumeb Smelter has on the biophysical and social environment (Synergistics, 2011). The EIA was undertaken in terms of best practice and pre-empted the need for an ECC in terms of the Namibian legislation. This process was undertaken prior to the February 2012 publishing of the Environmental Management Act Regulations. The ECC was issued on 26 October 2012.
2012	An EIA process was undertaken for the construction of the hazardous waste site within an old quarry site to the south of the Tsumeb Smelter (Synergistics, 2012). The ECC was issued in 2012.
2013	An EIA process was undertaken for the establishment of a general waste landfill site at the smelter in 2013 (Synergistics 2013). The ECC was issued in August 2013.
2013	An EIA process was undertaken for a new sulphuric acid plant in 2013 (Golder, 2013). The project was viewed as an environmental improvement project to reduce SO ₂ air emissions from the smelter and improve ambient air quality. The ECC was issued in 2014.
2014	An EIA process for the upgrading of the sewerage system at the smelter was undertaken by SLR in 2014 (SLR, 2014a). The ECC was issued in June 2014.
2014	An EIA process for a new 11kV power line was undertaken by SLR in 2014 (SLR, 2014b). The ECC was issued in June 2014.
2015	An EIA and EMP amendment process for hazardous waste site was undertaken by SLR in 2015 (SLR, 2015). The amendment would allow for additional hazardous waste streams to be disposed of at the smelter's hazardous waste site. The application was, however, withdrawn during August 2015 following the decision to only dispose of arsenic wastes at the site.
2016	An application for the renewal of the ECC for the smelter operations was lodged with MET during February 2016 (SLR, 2016). The renewal was issued in September 2016.

The aim of the current ESIA Amendment process is to consolidate all the separate ECCs listed in the above table under a single ECC to cover the upgrading and optimisation project and further operations of the Tsumeb Smelter. In addition, the ESIA includes a consolidated EMP for all DPMT operations (see Appendix K). The EMP consolidates the approved EMP documents for all the smelter components.

1.3.2 ESIA TEAM

SLR Environmental Consulting (Namibia) (Pty) Ltd (SLR) is the independent firm of consultants that has been appointed by DPMT to undertake the environmental impact assessment and related processes. Eloise Costandius, the project manager, has worked as an environmental assessment practitioner since 2005 and has been involved in a number of projects covering a range of environmental disciplines, including Faunal Specialist Studies, Basic Assessments, EIAs and EMPs. She has gained experience in a wide range of projects relating to mining (e.g. oil exploration and borrow pits), infrastructure projects (e.g. roads), and housing and industrial developments. Eloise holds a Masters Degree in Ecological Assessment and is registered as a professional natural scientist with the South African Council for Natural Scientific Professions. Werner Petrick, the project reviewer, has more than eighteen years of relevant experience in environmental management, conducting/managing EIAs, compiling EMPs and implementing EMPs and Environmental Management Systems. Werner holds a Masters Degree in Environmental Management and is certified as a lead environmental practitioner under the Environmental Assessment Professionals Association of Namibia (EAPAN). Immanuel Katali, the project assistant holds a B (Arts) in Geography and Environmental Studies and has 2 years of relevant experience in environmental management, conducting EIAs and compiling EMPs. The relevant curriculum vitae documentation is attached in Appendix A.

The environmental project team is outlined in Table 1-3.

TABLE 1-3: THE ENVIRONMENTAL PROJECT TEAM

Team	Name	Designation	Tasks and roles	Company
DPMT TEAM	Brent Johnson	Vice President: Environment	Responsible for the interface between DPMT and the environmental team, and for ensuring implementation of the EIA outcomes.	DPMT
	Pierre Reinecke	ESIA project coordinator		
Environmental Project Team	Eloise Costandius	Project Manager	Management of the process, team members and other stakeholders. Report compilation.	SLR Consulting
	Werner Petrick	Project Assistance and Reviewer	Report and process review	
	Immanuel Katali	Project Assistant	Assist with compilation of documents	
Specialists investigations	Gwendal Madec	Groundwater specialist	Groundwater and surface water assessment	Airshed Planning Professionals
	Jonathan Church	Surface water specialist		
	Gordon Kernick	Waste specialist	Waste management study	
	Hanlie Liebenberg-Enslin	Air quality specialist	Air quality and noise specialist assessments	
	Nicolette von Reiche	Noise specialist		

Team	Name	Designation	Tasks and roles	Company
	Tony Barbour	Social specialist	Socio-economic assessment	Independent social specialist
	Hugo van Zyl	Economics specialist		Independent economic specialist
	Jonny Myers	Community health specialist	Community and occupational health assessment	University of Cape Town
	Greg Kew			EOH Health
	Erika du Plessis	Stakeholder engagement specialist	Stakeholder engagement facilitator	African Stakeholder Engagement Consultants (AFSEC)

1.3.3 STRUCTURE OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

The main purpose of this EIA report is to assess all potential environmental and social impacts associated with the proposed upgrading and optimisation of the Tsumeb Smelter cumulative (taking the current activities and facilities into consideration) and to provide meaningful additional/amended management and mitigation measures to avoid or reduce the negative impacts and enhance positive impacts, where relevant.

The content of this ESIA report is informed by Section 15 of the above mentioned EIA Regulations. The required components of this report are included in Table 1-4 below:

TABLE 1-1: ESIA REPORT REQUIREMENTS STIPULATED IN THE 2012 EIA REGULATION UNDER EMA

EIA Regulation requirement	Reference in the ESIA report
The curriculum vitae of the EAP who compiled the report	Appendix B
A detailed description of the proposed listed activity	N/A
A description of the environment that may be affected by the activity and the manner in which the physical, biological, social, economic and cultural aspects of the environment may be affected by the proposed activity	Section 4
A description of the need and desirability of the proposed listed activity and identified potential alternatives to the proposed listed activity, including advantages and disadvantages that the proposed activity or alternatives may have on the environment and the community that may be affected by the activity	Sections 1.2 and 5
An indication of the methodology used in determining the significance of potential effects	Section 7
A description and comparative assessment of all alternatives identified during the assessment process	Sections 6 and 7
A description of all environmental issues that were identified during the assessment process, an assessment of the significance of each issue	Section 7, Appendices D to I (specialist

and an indication of the extent to which the issue could be addressed by the adoption of mitigation measures	assessments), and Appendix K (EMP).
An assessment of each identified potentially significant effect, including - <ul style="list-style-type: none"> • cumulative effects; • the nature of the effects; • the extent and duration of the effects; • the probability of the effects occurring; • the degree to which the effects can be reversed; • the degree to which the effects may cause irreplaceable loss of resources; and the degree to which the effects can be mitigated	Section 7 and Appendices D to I
A description of any assumptions, uncertainties and gaps in knowledge	Section 8 and Appendices D to I
An opinion as to whether the proposed listed activity must or may not be authorised, and if the opinion is that it must be authorised, any conditions that must be made in respect of that authorisation	Section 9
A non-technical summary of the information	Executive summary

The Environmental Management Plan included in Appendix K includes the following as per the requirements of Section 8 (j) of the EMA regulations:

(j) a management plan, which includes –

(aa) information on any proposed management, mitigation, protection or remedial measures to be undertaken to address the effects on the environment that have been identified including objectives in respect of the rehabilitation of the environment and closure;

(bb) as far as is reasonably practicable, measures to rehabilitate the environment affected by the undertaking of the activity or specified activity to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development; and

(cc) a description of the manner in which the applicant intends to modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation remedy the cause of pollution or degradation and migration of pollutants.

2 ASSESSMENT APPROACH AND PUBLIC CONSULTATION PROCESS

The scoping phase of the assessment for the project was completed and described in the Scoping Report. The Final Scoping Report was submitted to MET in June 2016. MET accepted the Final Scoping Report on 4 August 2016.

The ESIA Report presents the ESIA and EMP for the upgrading and optimisation of the Tsumeb Smelter. This chapter sets out the steps followed in the ESIA process to date.

2.1 INFORMATION COLLECTION

SLR used various sources to identify both the environmental issues associated with the proposed amendments and the terms of reference for the required investigations. The main sources of information for the preparation of both the scoping and ESIA reports include:

- Project information provided by DPMT:
 - Tsumeb Smelter Expansion Pre-feasibility Study report (WorleyParsons, 2015);
 - Air and water quality monitoring results;
 - Closure Plan (Golder, 2016)
- Site visits by SLR;
- Consultation with the DPMT project team (additional technical information provided by DPMT and their project team and engineers);
- Previous EIA Reports and other specialist reports compiled for the DPMT smelter facility:
 - Tsumeb Smelter EIA (Synergistics, 2011);
 - General Waste Landfill Site (Synergistics, 2013);
 - Sulphuric Acid Plant EIA (Golder, 2013);
 - Kliplime Quarry EMP (Synergistics, 2013);
 - Sewage Treatment Plant EIA (SLR, 2014a);
 - 11kV Power line EIA (SLR, 2014b);
 - Scoping Report (including assessment) for the DPMT hazardous waste site amendment (SLR, 2015);
 - Baseline soil, land capability and land use assessment (Red Earth, 2016);
 - Environmental Management Progress Report – Contaminated Land Assessment (Weiersbye, 2016);
 - Biodiversity Assessment Report (Enviro Dynamics, 2016); and
 - Amended EMP for the Tsumeb Smelter (SLR, 2016)
- Consultation with IAPs and with relevant authorities; and
- Atlas of Namibia (Mendelsohn *et al.*, 2009)

2.2 SPECIALIST STUDIES

The proposed terms of reference for further specialist investigations were developed as part of the scoping phase and were presented in the Scoping Report.

Based on the terms of reference and findings of the Scoping phase, specialists were required to inform the various impacts that the proposed amendments may have on the physical and socio-economic environments for inclusion in the ESIA Report.

The following specialist studies were conducted:

- Air Quality Impact Assessment Report (Airshed, 2017);
- Groundwater and Surface Water Report (SLRa, 2016);
- Waste Management Report (SLRb, 2016);
- Noise Impact Assessment (Airshed, 2017);
- Community Health Assessment (Myers, 2016) and
- Socio-Economic Impact Assessment (Barbour & Van Zyl, 2017).

The specialist studies are attached to this report in Appendices D to I.

2.3 IMPACT ASSESSMENT METHODOLOGY

The criteria used to assess the impacts and the method of determining the significance of the impacts is outlined in Section 7.1. This method complies with the EIA Regulations: EMA, 2007 (Government Gazette No. 4878) EIA regulations and was used by the relevant specialists to conduct their impact assessments.

2.4 PUBLIC PARTICIPATION PROCESS

The aim of the public participation process (PPP) for this ESIA is to ensure that all persons or organisations that are interested in or affected by the project are informed of the issues and can register their views and concerns. A description of the PPP is provided below.

2.4.1 SCOPING PHASE

2.4.1.1 STAKEHOLDERS

Key stakeholders were identified as those people who are interested or potentially affected by the proposed project. Table 2-1 below provides a broad list of stakeholders that were engaged with during the Scoping and ESIA process thus far.

TABLE 2-1: DUNDEE PRECIOUS METALS STAKEHOLDERS

Stakeholder Grouping	Organisation
Local government – councillors and key officers	Tsumeb Town Council
Government Ministries	<ul style="list-style-type: none"> Ministry of Environment and Tourism (MET) <ul style="list-style-type: none"> Directorate of Environmental Affairs Ministry of Health and Social Services Ministry of Labour, Industrial Relations and Employment Creation Ministry of Agriculture, Water and Forestry Ministry of Industrialisation, Trade and SME Development Ministry of Finance Ministry of Public Enterprises Ministry of Poverty Eradication
Non-Governmental Organisations (NGOs)	<ul style="list-style-type: none"> Earth Life Namibia Wildlife Society of Namibia Birdlife Africa WWF in Namibia Earth Organisation, Namibia Bankwatch
Industries in the Tsumeb region	Various industries
Unions	Mineworkers Union, Namibia National Labour Union, National Union of Namibian Workers
Media	Newspapers: The Namibian, Republikein, The Villager/Prime Focus, Confidente, Namibian Sun, NAMPA, New Era Newspaper, Informante, Allgemeine Zeitung
Other interested and affected parties	Any other people with an interest in, or who may be affected by, the proposed project.

2.4.1.2 STEPS IN THE CONSULTATION PROCESS

Table 2-2 sets out the steps in the consultation process that have been conducted during the Scoping Phase:

TABLE 2-2: CONSULTATION PROCESS WITH IAPS AND AUTHORITIES DURING THE SCOPING PHASE

TASK	DESCRIPTION	DATE
Notification - regulatory authorities and IAPs		
Consultation with MET	SLR discussed the project proposal with MET telephonically and confirmed the required Scoping and ESIA amendment process	February 2016
IAP identification	The existing DPMT stakeholder database was used. This database is updated throughout the process. A copy of the IAP database is attached in Appendix C.	March 2016 and throughout the process

TASK	DESCRIPTION	DATE
Background Information Document (BID)	<p>BIDs with covering letters were distributed electronically (where possible) to relevant authorities and IAPs on DPMT's stakeholder database and copies were made available on request to SLR.</p> <p>Hard copies of the BID were also made available during the public scoping meetings in Tsumeb.</p> <p>The purpose of the BID was to inform IAPs and authorities about the proposed optimisation and upgrade project, the assessment process being followed, possible environmental impacts and ways in which IAPs could provide input to SLR. Attached to the BID was a registration and response form, which provided IAPs with an opportunity to submit their names, contact details and comments on the project.</p> <p>A copy of the BID is attached in Appendix C.</p>	April 2016
Site notices and pamphlet distribution	<p>A site notice was placed at the entrance to the smelter facility.</p> <p>A4 posters advertising the project and public meetings were put up at the municipality. Notification letters with meeting invitations were hand delivered to over 50 businesses in Tsumeb on 19 April 2016.</p> <p>A photo of the site notice is attached in Appendix C</p>	April 2016
Newspaper Advertisements	<p>Block advertisements were placed as follows:</p> <ul style="list-style-type: none"> The Namibian (8 and 15 April 2016) Republikein (8 and 15 April 2016) <p>The newspaper advertisements provided information of the proposed project, the availability of the BID and the time and venues of the planned public scoping meetings.</p>	April 2016
Radio advertisements	<p>Radio advertisements announcing the project and advertising the public scoping meetings were broadcast on the evenings of 18 and 19 April 2016. These advertisements were broadcast on NBC radio stations in Afrikaans, English and Oshiwambo.</p>	April 2016
Public and focus group meetings and submission of BID comments		
Public and focus group meetings	<p>The following public meetings and focus group meetings were held as part of the Scoping phase of the ESIA:</p> <ul style="list-style-type: none"> A public meeting was held at the Makalani Hotel in Tsumeb on 20 April at 11:00. A focus group meeting was held with the Ondundu Village residents at the Ondundu School Hall on 20 April at 18:00. A focus group meeting was held with the Tsumeb Town Council members, including the executive mayor, at the Tsumeb Municipality council chambers on 21 April at 15:00. A focus group meeting was held at the community hall in Nomtsoub on 21 April at 18:00. <p>The same project and ESIA information was shared at all of the above mentioned meetings. Project information was presented in English and Afrikaans, with translators available should information be requested in Oshiwambo or Damara. A copy of the presentation is attached in Appendix C.</p>	April 2016
Comments and Responses	<p>Minutes of the meetings and a comments and responses report on initial comments received on the BID were appended to the draft Scoping Report.</p>	
Review of draft Scoping Report		
IAPs and authorities (excluding MET) review of scoping report	<p>Notifications regarding the availability of the draft Scoping Report were sent via email and text message to all parties registered on the project database and/or parties that showed an interest in this ESIA process. An electronic copy of the report was made available online and CDs on written request. Hard copies of the report were made available at the Tsumeb public library and the DPMT Information Centre.</p> <p>Registered IAPs were given two weeks to review the report and submit</p>	June 2016

TASK	DESCRIPTION	DATE
	comments in writing to SLR. The Scoping Report comment period closed on 29 June 2016. Only one written comment was received during the formal comment period.	
MET review and acceptance of Scoping Report	A copy of the final Scoping Report, including IAP review comments was submitted to MET on 8 July 2016. Acceptance of the Scoping Report was issued by MET on 4 August 2016.	July - August 2016

2.4.1.3 SUMMARY OF ISSUES RAISED

The issues raised by IAPs to date pertain to the following:

- Air quality and health impacts;
- DPMT's reputation;
- Socio-economic issues;
- Project design;
- ESIA process and specialist studies
- Public participation process;
- Groundwater impacts;
- Noise impacts; and
- Waste disposal.

All comments were provided to the independent specialist team for consideration in their assessments. An updated Issues and Responses Report is included in Appendix C. It summarises all the comments received to date with responses and reference to the EIA Report, EMP and specialist studies, where relevant.

2.4.2 PUBLIC CONSULTATION AND REVIEW OF DRAFT EIA REPORT

Table 2-3 sets out the steps in the consultation process that have been conducted during the EIA Phase to date.

TABLE 2-2: CONSULTATION PROCESS WITH IAPS AND AUTHORITIES DURING THE SCOPING PHASE

TASK	DESCRIPTION	DATE
Focus group meetings to provide feedback on specialist findings		
Public and focus group meetings	<p>Public and authority meetings were held in Tsumeb on 8 and 9 March 2017 in order to provide feedback on the key findings of the specialist studies and ESIA process prior to distribution of the Draft ESIA report. Meeting invitations were sent to all parties on the project database via E-mail and text message. The meetings were held as follows:</p> <ul style="list-style-type: none"> • 8 March 2017, 10:00 – Focus group meeting with the Tsumeb Town Council members at the Tsumeb Municipality council chambers; • 8 March 2017, 18:00 - Focus group meeting with the Ondundu Village residents at the Ondundu School Hall; • 9 March 2017, 10:00 - Focus group meeting at the Makalani Hotel in Tsumeb; and • 9 March 2017, 18:00 - Focus group meeting the community hall in 	March 2017

TASK	DESCRIPTION	DATE
	Nomtsoub. The same project and ESIA information was shared at all of the above mentioned meetings. Project information was presented in English and Afrikaans, with translators available should information be requested in Oshiwambo or Damara. A copy of the presentation is attached in Appendix C.	
Comments and Responses	Minutes of the meetings are included in Appendix C.	

The Executive summary of the ESIA report and information on the public comment period on the draft report will be distributed by e-mail on 19 April 2017 to all IAPs and Government bodies registered on the database. A full electronic copy of the report including appendices will be made available on request to SLR and on the SLR website.

Hard copies of the report will be made available at the Tsumeb Public Library and at the DPMT Information Centre.

The public comment period will be from 19 April to 29 May 2017. A dedicated feedback session on the findings of the specialist studies will also be presented to DPMT employees during the comment period.

The final ESIA Report, including additional review comments from IAPs will be submitted to MET for their review and decision by mid-June 2017.

3 LEGAL FRAMEWORK

The Republic of Namibia has five tiers of law and a number of policies relevant to environmental assessment and protection, which includes:

- The Constitution
- Statutory law
- Common law
- Customary law
- International law

Relevant policies currently in force include:

- The EIA Policy (1995).
- Namibia's Environmental Assessment Policy for Sustainable Development and Environmental Conservation (1994).
- The National Climate Change Policy of Namibia (September 2010).
- Minerals Policy of Namibia (2004).
- Policy for the Conservation of Biotic Diversity and Habitat Protection (1994).

As the main source of legislation, the Constitution of the Republic of Namibia (1990) makes provision for the creation and enforcement of applicable legislation. In this context and in accordance with its constitution, Namibia has passed numerous laws intended to protect the natural environment and mitigate against adverse environmental impacts.

The environmental regulations are guided and implemented by the Department of Environmental Affairs (DEA) within the Ministry of Environment and Tourism (MET).

The section below summarises the various applicable laws and policies.

3.1 SUMMARY OF APPLICABLE ACTS & POLICIES

In the context of the Tsumeb Smelter Upgrade and Optimisation Project, there are several laws and policies currently applicable. They are reflected in Table 3-1.

A list of permits and approvals currently held by DPMT as well as a list of additional pending permit applications are provided in Section 3 of the Consolidation EMP in Appendix K.

TABLE 3-1: RELEVANT LEGISLATION AND POLICIES FOR THE TSUMEB SMELTER UPGRADE AND OPTIMISATION PROJECT

YEAR	NAME	Natural Resource Use (energy & water)	Emissions to air (fumes, dust & odours)	Emissions to land (non-hazardous & hazardous)	Emissions to water (industrial & domestic)	Noise (remote only)	Visual	Vibrations	Impact on Land use	Impact on biodiversity	Impact on Archaeology	Emergency situations	Socio-economic	Safety & Health	Other
1969	Soil Conservation Act (No. 76 of 1969)			X											
1990	The Constitution of the Republic of Namibia of 1990	X	X	X	X	X	X	X	X	X	X	X	X	X	
1997	Namibian Water Corporation Act, 12 of 1997	X											X		
2013	Water Resources Management Act 11 of 2013	X			X								X		
2007	Environmental Management, Act 7 of 2007	X	X	X	X	X	X	X	X	X	X		X	X	
2012	Regulations promulgated in terms of the Environmental Management, Act 7 of 2007														
1975	Nature Conservation Ordinance 14 of 1975	X			X					X	X				
1976	Atmospheric Pollution Prevention Ordinance 11 of 1976		X												

YEAR	NAME	Natural Resource Use (energy & water)	Emissions to air (fumes, dust & odours)	Emissions to land (non-hazardous & hazardous)	Emissions to water (industrial & domestic)	Noise (remote only)	Visual	Vibrations	Impact on Land use	Impact on biodiversity	Impact on Archaeology	Emergency situations	Socio-economic	Safety & Health	Other
1995	Namibia's Environmental Assessment Policy for Sustainable Development and Environmental Conservation	X	X	X	X	X	X	X	X	X	X	X		X	
2004	Pollution Control and Waste Management Bill (3rd Draft September 2003)		X	X	X	X									
1974	Hazardous Substance Ordinance, No. 14 of 1974														X
1992	Labour Act, No. 6 of 1992 and its related Health and Safety Regulations												X	X	
2015	Public and Environmental Health Act, No. 86 of 2015	X	X	X	X	X			X				X	X	X

In addition, the following International Conventions, which i.t.o. Section 144 of the Constitution, automatically form part of Namibian law may also apply:

- The Convention on Biodiversity, 1992
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989
- The United Nations Framework Convention on Climate Change (UNFCCC)
- United Nations Convention on the Law of the Sea, 1982
- Vienna Convention for the Protection of the Ozone Layer, 1985
- Montreal Protocol on Substances that Deplete the Ozone Layer, 1987
- Kyoto Protocol on the Framework Convention on Climate Change, 1998

Further details regarding relevant legislation as it applies to the different specialist fields are provided in the specialist studies in Appendices D to I as well as in Appendix J.

4 DESCRIPTION OF THE CURRENT ENVIRONMENT

This section was compiled utilising the following sources of information:

- Digital Atlas of Namibia which was compiled by the University of Cologne (Universität zu Köln) based on data sourced from the Directorate of Environmental Affairs, Ministry of Environment and, Tourism (http://www.uni-koeln.de/sfb389/e/e1/download/atlas_namibia/index_e.htm);
- Namibian Weather Services website (www.namibiaweather.info);
- Visual observations during site visits by SLR;
- Google Earth; and
- Specialist assessments.

4.1 CLIMATE

4.1.1 TEMPERATURE

Monthly mean and hourly maximum and minimum temperatures are given in Table 4-1. Temperatures range between 6 °C and 44 °C. The highest temperature was recorded in September and October and the lowest in June. During the day, temperatures increase to reach a maximum at around 15:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 07:00 i.e. just before sunrise.

TABLE 4-1: MINIMUM, MAXIMUM AND AVERAGE TEMPERATURES RECORDED AT THE PLANT HILL SITE

Month	Maximum Hourly Temperature (°C)	Minimum Hourly Temperature (°C)	Average Temperature (°C)
Jan	38	14	27.7
Feb	39	12	26.6
Mar	38	11	26.1
Apr	33	8	20.9
May	33	8	21.3
Jun	31	6	19.9
Jul	30	11	20.1
Aug	40	8	24.4
Sep	44	12	29.4
Oct	44	12	30.8
Nov	43	12	28.1
Dec	42	19	29.1

4.1.2 RAINFALL AND EVAPORATION

Tsumeb has an annual average rainfall of 520 mm with most of the rainfall occurring in the summer months (October to April). Approximately two thirds of the rainfall occurs in the months of January, February and March, with the highest number of productive rainfall days (i.e. days with rainfall of 10 mm and more) registered in January and February.

4.1.3 WIND

Wind data are recorded at the Tsumeb weather station and at DPMT's five sampling stations (see Figure 4-9 for locations). Average, day and night time wind roses for the period January 2013 to October 2016 as measured at the Plant Hill station, immediately south of the Smelter complex, are shown in Figure 4-1. At the Plant Hill station the wind field is uniform with frequent south-easterly winds. There are also occasionally winds from the north. Calm conditions prevailed 1.6% during the recording period with a period average wind speed of 2.8 m/s. During day-time the wind field is mostly characterised by wind from the east-southeast, an average wind speed of 3.1 m/s and 0.7% calm conditions. The average wind speed decreased to 2.5 m/s during night-time hours and blew mostly from the south-southeast with 1.6% calm conditions.

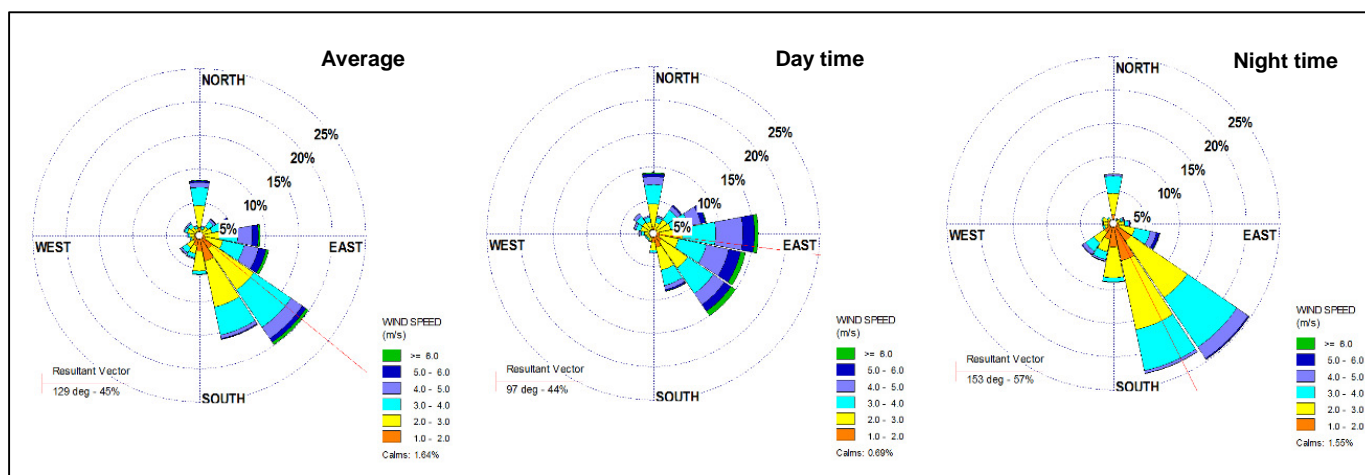


FIGURE 4-1: PERIOD AVERAGE WIND ROSES FROM THE PLANT HILL STATION DATA (JANUARY 2013 – OCTOBER 2016)

Wind roses for data recorded at all the sampling stations during the 2013-2014 recording period are shown in Figure 4-2. The results show an average wind field dominated by winds from the east, east-southeast and south-east with average wind speeds between 3.1 m/s. The strongest winds (more than 6 m/s) were from the north-north-west and occurred mostly during the day. The day-time wind field is dominated by wind from the westerly and north easterly sectors. During the night, wind speeds decreased and the wind field was dominated by winds from the north-east. Wind speeds recorded at the Sewerage Works (west of the Smelter) were notably higher than wind speeds at other stations. The wind field recorded at the Information Centre (in Tsumeb town, south of the Smelter) does not show the frequent south-easterly flow observed at the other stations.

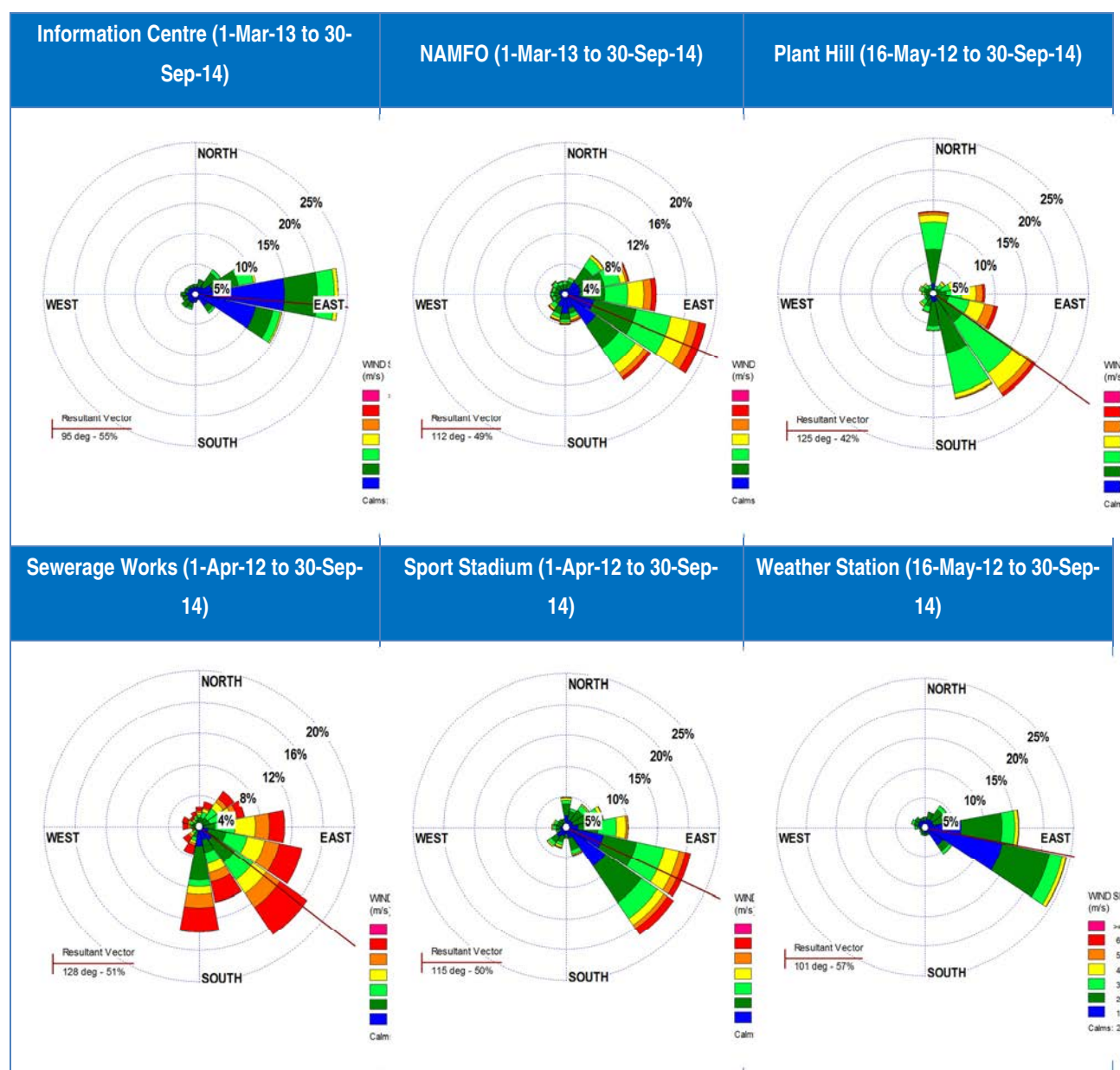


FIGURE 4-2: WIND SPEED AND DIRECTION RECORDED AT TSUMEB (MARCH 2012 - SEPTEMBER 2014)

4.2 TOPOGRAPHY

The town of Tsumeb is located in the northern section of the central Namibian Plateau on the northern edge of the Otavi Mountainland which is characterised by a typical karst landscape. The town is relatively flat (1 300 meters above mean sea level [mamsl]) and flanked to the south and east by the Otavi Mountains. An east-west ridge separates the town from the smelter complex (1 257 mamsl) which is located at the base of a valley to the north of the town. The terrain of the area is characterised by gentle undulating relief around the smelter complex. The Waterberg plateau is located approximately 12 km to the south-west of the smelter complex. The regional topography is shown in Figure 4-3.

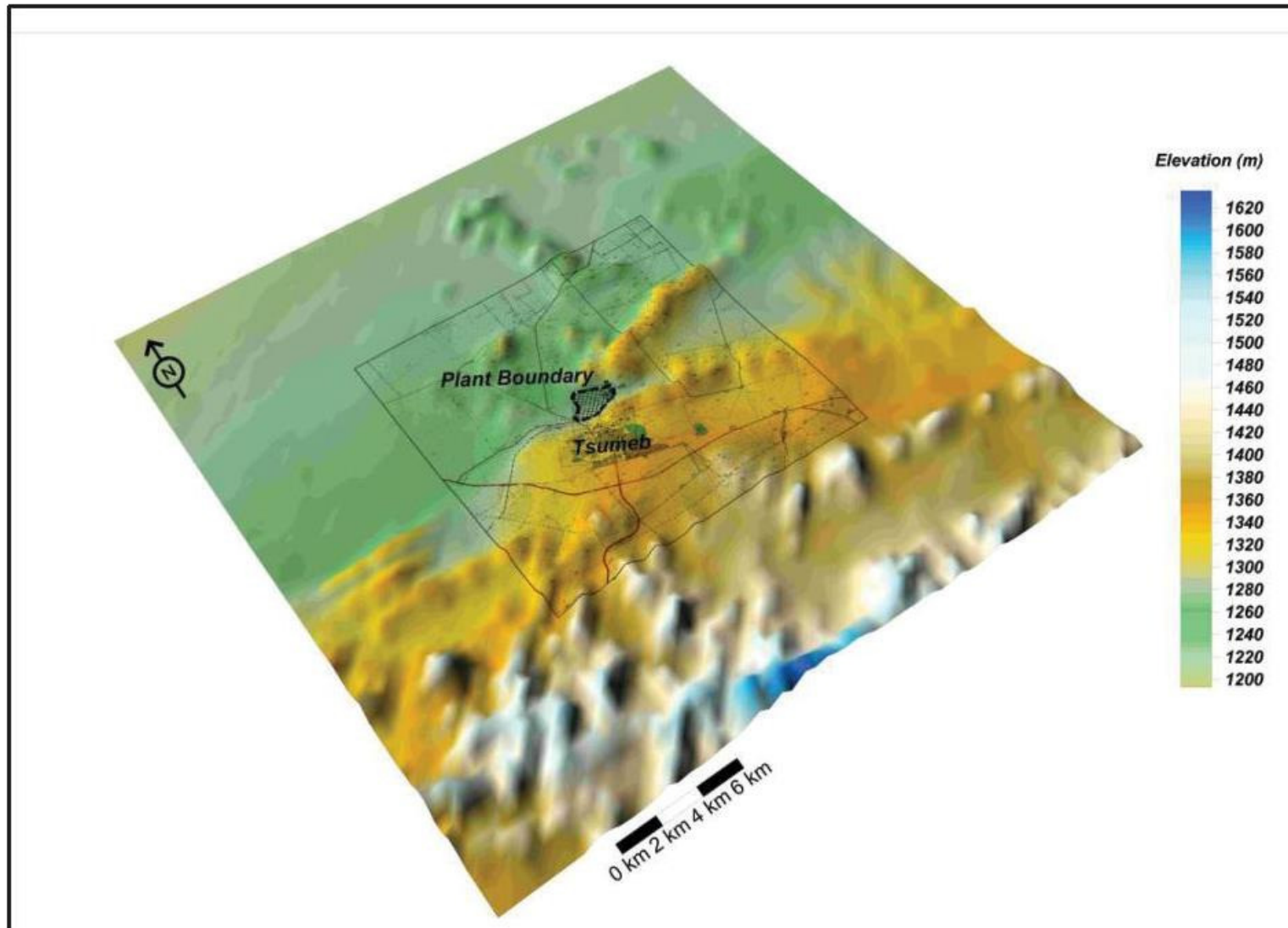


FIGURE 4-3: TOPOGRAPHY OF TSUMEB AND SURROUNDS

4.3 GEOLOGY

The period 900-950Ma was marked by extensive continental fragmentation with geosynclinal deposition in a major Late Proterozoic – Early Paleozoic tectono-thermal event referred as Pan-African event (Master, 1991). Downward flexing of the craton margins produced extensive intra-cratonic foreland basins (Thomas & al, 1993). The late Proterozoic to Early Palaeozoic Damara belt forms part of the Pan-African mobile system belt, which surrounds and bisects the African continent (Martin 1983, Miller 1983a).

The NE-trending Pan-African Damara Belt is 400 km wide and is located between the Congo and the Kalahari Cratons in the South West region of Southern Africa.

The Damara Supergroup consists of a north east trending intracontinental arm and a north south trending coastal arm with a present outcrop width in Namibia of 150 km. The triple junction between the two arms is located off the coast near Swakopmund (Miller, 1983c). Evolution of the belt involves a complex history which includes rifting, spreading, convergence and collision of Kalahari and Congo Cratons. In addition to this, deformation, metamorphism and magmatism accompanied the collision. Subsequently the belt underwent episodes of continental rifting, ocean floor spreading, glaciation, subduction, collision and metamorphism over a time span of about 250 million years.

With regards to stratigraphy, rocks of the Damara Supergroup were deposited on an Archean granite-gneiss Basement exposed in the northern and southern zones, and in the inlier in the centre of the belt (Jacob & Kroner, 1977). The Basement complex crops out in several major inliers along the northern and southern margins of the Damara province, as well as numerous small inliers in the central parts. A stratigraphic column for the Otavi Mountainland (OML) is shown in detail in Table 4-2, with the regional geology depicted in Figure 4-4.

The Nosib Group unconformably overlies the Basement Complex. It consists of the Nabis, Chuos, Berg Aukas and Gauss formations. The environment of deposition progressively developed from predominantly fluvial to marine when finer grained shales were deposited (Kamona & Gunzel, 2006).

The Otavi Group consists of Abenab and the Tsumeb subgroups which are unconformably overlying the Nosib Group and the Basement Complex (Hedberg, 1979). The latest, the Tsumeb Subgroup, is subdivided into 8 litho-zones (T1 to T8) from the clastic Ghaub Formation to the carbonate dominant Maieberg, Elandshoek as well as the Hüttenberg Formations.

The **Ghaub Formation**, referred to as T1, is a glacio-marine tillite with lenses of dolomite and schist.

The **Maieberg Formation** is a platform slope, deep water deposit and overlies the Ghaub Formation. The lower Maieberg Formation (T2) consists of slump brecciated and laminated carbonate and argillaceous sediments. The upper Maieberg Formation (T3) comprises bedded and finely laminated carbonates.

The **Elandshoek Formation** conformably overlies the Maieberg Formation. It covers most of the northern limb of the Otavi Valley north of Kombat Mine. The lower Elandshoek Formation (T4) comprises of massive dolomite and is responsible for the rugged geomorphologic terrain of the northern limb of the

Otavi Valley. The brecciation is generally intensive and therefore T4 is regarded as an important aquifer (Van der Merwe, 1986). The upper Elandshoek Formation (T5) is fairly thin and not easily distinguishable from T4.

TABLE 4-2: GEOLOGY AND STRATIGRAPHY OF THE AREA

(Stratigraphic Column for the Otavi Mountainland, revised after Hoffmann and Prave (2008))

SUPER GROUP	GROUP	SUB GROUP	Age, Ma	FORMATION	LITHOLOGY	ZONE	
DAMARA	MULDEN		550	Tschudi	Arkose, feldspathic sandstone, grit conglomerate		
			570	Kombat	Phyllite, interbedded with lenticular dolostone		
		Disconformity					
		Kombat Ore Bodies	760?	Hüttenberg	Thin Bedded Light dolostone with algal markers and chert beds, prominent pisolite-oolite chert beds at the top	T8	
	OTAVI	Kombat (Cu - Pb - Ag)	Thin Bedded Dark Dolomites with Phyllite, black oolitic chert, anhydrite horizons silicified reef (Tschudi area)		T7		
			Thin Bedded Limestone and Shale				
			Bedded light Dolomite and Chert (Algal) stromatolites		T6		
			Tsumeb (Cu - Pb - Zn - Ag)	Elandshoek	Massive and Bedded Light Dolomite	T5	
		Massive Light Dolomite, with bedded dolostone			T4		
		Maieberg	Thin Bedded Dolomite	T3			
			Thin Bedded Limestone, Quartzite	T2			
			Bedded Dolomite, Thin-bedded Limestone, greenish-grey shale				
			Thin bedded Limestone and Shale				
			Localised Tillite and Limestone				
		Keilberg	Fine grained laminated to massive pale pink dolostone				
		Ghaub	Massive carbonate class dominated diamictite	T1			
			Medium to thin bedded diamictite with dropstones				
		Abenab (Pb - Zn- V)	Abenab	Disconformity	Auros	Bedded Dolomite (Quartz Clusters)	
						Massive Dolomite (Algal – Columnar)	
						Bedded Limestone and Shale	
Massive Dolomite (Algal – Columnar)							
Bedded Limestone and Shale							
Massive Dolomite (Algal – Cryptozoon)							
	Bedded Limestone and Shale						
	Massive Dolomite (Jasperoid)						
	Bedded Limestone and Shale						
Berg Aukas (Pb - Zn - V)	NOSIB	Unconformity	Gruis	Pink and light pinkish grey fine grained, micritic dolostone and chert, oolite and stromatolite at top, interbedded with shale locally			
			Gauss	Very Light grey, pinkish grey and buff enterolithic dolomitic dessication structures and microbial, stromatolite, micrite			
				Very light to medium grey and buff massive dolostone with colloform texture local stromatolite and oolite			
				Grey to light grey, buff and pink medium and thin bedded and laminated dolostone			
			830	Berg Aukas	Dark grey microbial laminated/stromatolitic dolostone, local chert laminated rhythmite dolostone		
				Varianto(Chuos)	Diamictite, pebbly grit, iron formation		
		840	Nabis	Shale, Phyllite			
				Conglomerate, Arkose, Quartzite			
			1000				
1800							
BASEMENT COMPLEX					Diabase, Granite and Gneiss, Diorite, Gabbro, Serpentinite		

The **Hüttenberg Formation** marks the change from the deep sea environment observed in the Elandshoek Formation to shallow lagoon shelves. It consists of a grey bedded basal dolomite,

stromatolite rich (T6), overlain by two upper units, a massive dark and bedded dolomite with chert and with phyllite (T7) and T8 is marked by pisolite and oolite.

The **Mulden Group** is characterised by the **Kombat Formation** in the southern part of the OML, which consists of a siliciclastic molasses (poorly graded phyllite, arkose, argillite and siltstone) deposited syn-tectonically during the early stage of the Damara Orogeny, and the **Tschudi Formation** (Arkose and feldspathic sandstone) in the northern part of the OML, and is separated from the Tsumeb Subgroup by an angular unconformity.

The town of Tsumeb lies on the northern edge of the OML and the dolomites of the Otavi Group characterise the area. The sandstones of the Mulden Group have been preserved in the Tschudi Syncline which extends in an east-west direction and is the representative geology of most of the area covered by the town (see Figure 4-4).

The dolomites to the north of the town house the Tsumeb deposit located in a pipe structure extending to a depth of 1 800 m and formed by the karstification process (Grünert, 2000). The deposit contains an extraordinary diversity of ores including lead, copper, zinc, silver, arsenic, antimony, cadmium, cobalt, germanium, gallium, iron, mercury molybdenum, nickel and tin as well as vanadium. The Tsumeb Smelter was established to allow for the processing of this polymetallic deposit.

4.4 GROUNDWATER

The town of Tsumeb falls within the Etosha Basin Hydrogeological Region. Groundwater occurs in the Tsumeb Dolomitic Aquifer with the Mulden Sandstones acting as an aquiclude. The Smelter site is located on the Elandshoek and Hüttenberg Formation lithozones in an ESE-WNW sloping valley formed as part of an anticlinal structure. The groundwater is expected to move in fold axes, pressure relief joints, faults or on lithological contact zones (see Figure 4-5).

4.4.1 GROUNDWATER LEVELS

The average natural groundwater levels in Tsumeb are at approximately 1 210 mamsl (60 m below the land surface in the town area) with little seasonal fluctuation in the levels.

The Tsumeb Mine was operational from 1907 to 1996, temporarily closed until 2000 then re-commissioned for a short period. (GCS, July 2013). Dewatering occurred at Shaft No.1 at the old Tsumeb Mine, south-west of the smelter. During 2000 water was pumped from the shaft for mining of mineral specimens from the upper levels of the mine (approximately 250 m below ground surface) at a rate of 350 m³/hr (WSP Walmsley, 2004). It is understood that during actual mining operations the water was pumped from a much greater depth. The shaft is approximately 1 600 m deep.

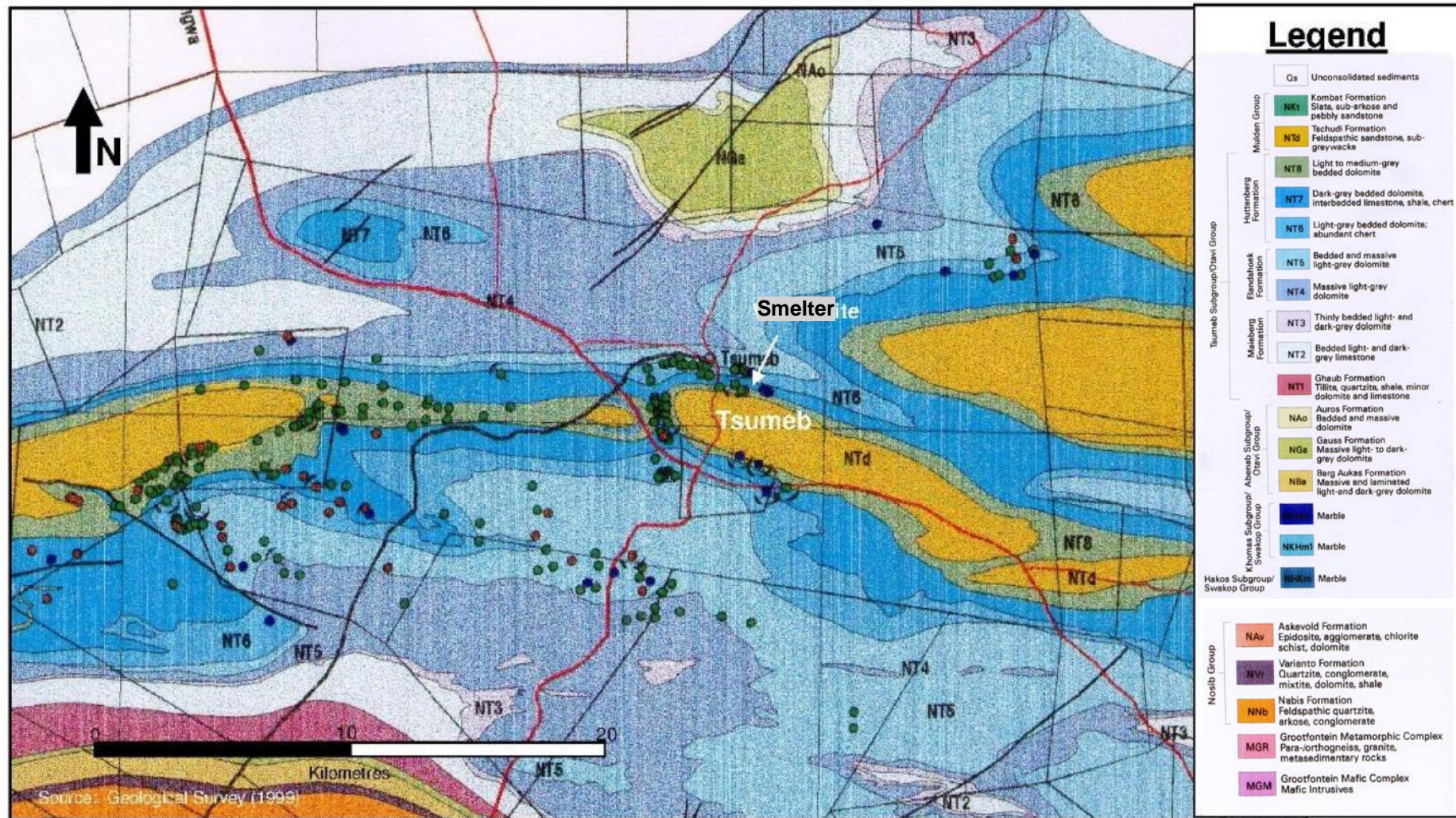


FIGURE 4-4: REGIONAL GEOLOGY OF TSUMEB AND SURROUNDS (WSP WALMSLEY, 2004)

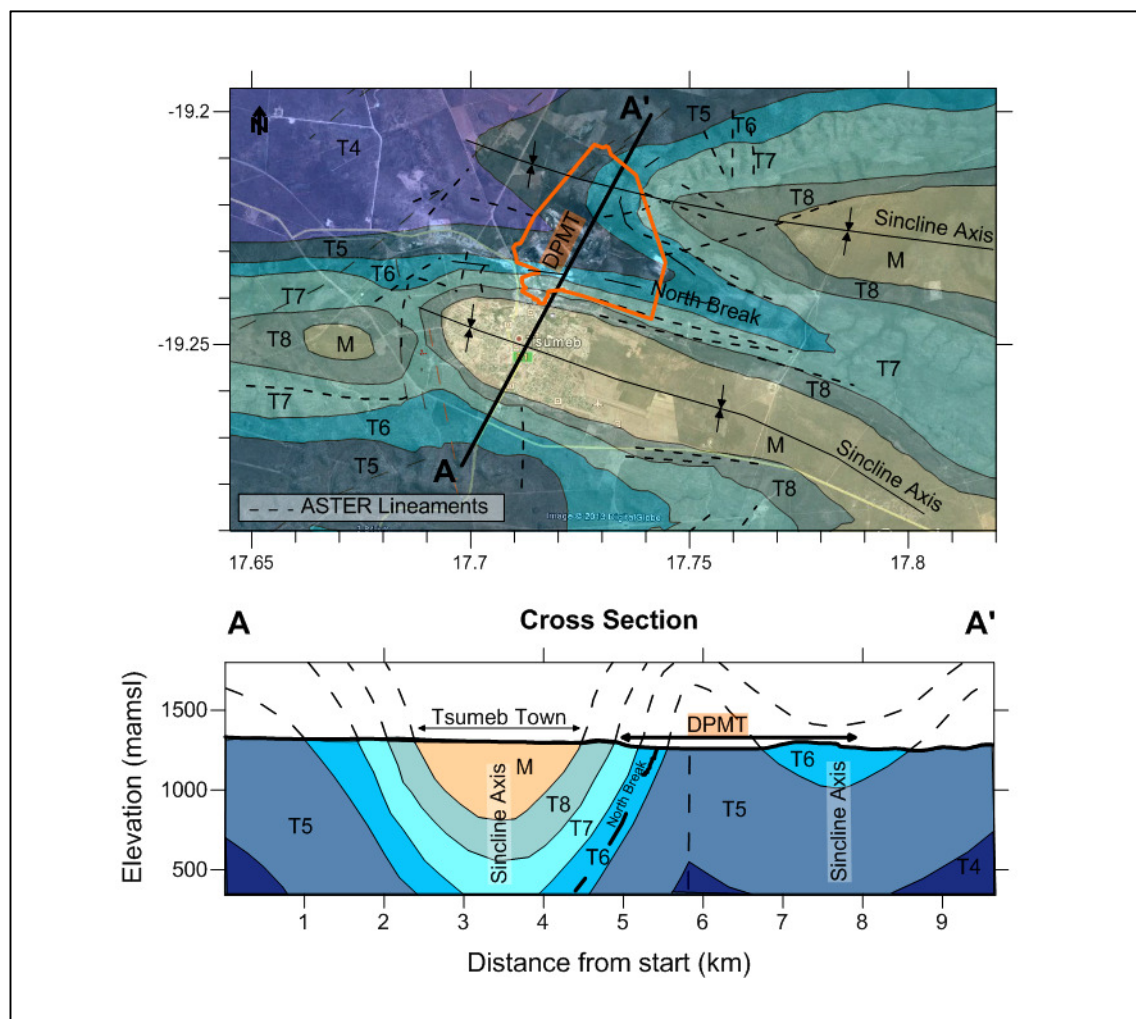


FIGURE 4-5: LOCAL GEOLOGY AROUND THE TSUMEB SMELTER, WITH SW-NE CROSS SECTION (GCS, 2013 AND SUBSEQUENTLY MODIFIED BY J. NEL, GCS)

4.4.2 GROUNDWATER FLOW

The natural groundwater flow from Tsumeb is in a northerly direction. The dolomite of the Hüttenberg Formation has high transmissivity and it is estimated that water migrates at a rate of approximately 1.08m/day or 360 m per annum (GCS, 2013), although secondary fracture flow in the area may result in localised acceleration of the groundwater flow rates. Predicted groundwater flow directions are illustrated in Figure 4-6 via an indication of groundwater gradients. The hills are considered a recharge zone for the groundwater.

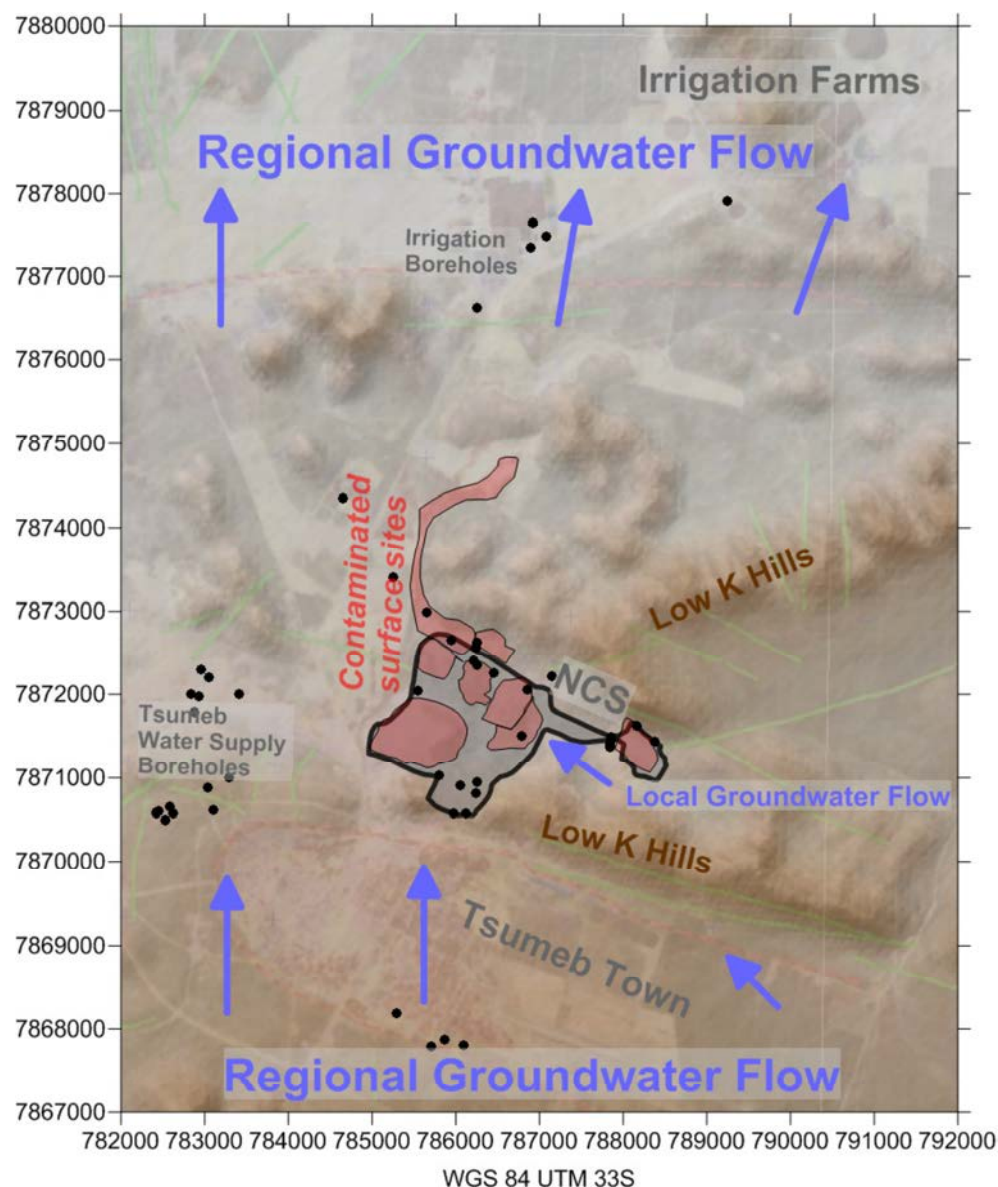


FIGURE 4-6: PREDICTED GROUNDWATER FLOW DIRECTIONS AT THE TSUMEB SMELTER COMPLEX (INDICATED AS NCS – NAMIBIAN CUSTOM SMELTERS; GCS, 2014)

4.4.3 GROUNDWATER QUALITY

Based on a hydrocensus undertaken in November 2012, GCS (May 2013) summarises the background groundwater quality as follows:

- High calcium, magnesium, bicarbonate water is encountered as expected from dolomitic water.
- pH values between 6.9 and 7.4 were measured in the hydrocensus boreholes. pH across boreholes is stable.
- Elevated concentrations, above Namibian drinking water standards, of sulphate (SO_4), arsenic (As) and molybdenum (Mo) were measured at the boreholes situated on the smelter site.
- Elevated iron (Fe) is also observed in all boreholes and is probably a result of the mineralogical composition of the rock.

It is important to view the groundwater quality monitoring results against some background values for the larger karst region, specifically when looking at arsenic pollution. Data from wider area studies do indicate elevated arsenic concentrations in areas not previously affected by mining which may be reflective of naturally high background arsenic levels in the geology.

Results of DPMT's July 2015 groundwater sampling round showed that only the Calcine- and Return Boreholes (see Figure 4-7) had arsenic concentrations exceeding the Namibian Guideline values for drinking water. All other boreholes had concentrations falling within the Group B or better quality drinking water according to the Guideline.

Groundwater monitoring boreholes within the DPMT site were increased from 12 to 20 during October 2015. DPMT is aiming to further expand the groundwater monitoring borehole network and will commence with planning for the establishment of additional boreholes in 2017. Groundwater samples were taken monthly from the new monitoring network from February to July 2016. During this period arsenic levels of higher than 0.1 mg/l were recorded at nine of the monitoring boreholes on the smelter site. The highest levels were recorded at the new monitoring boreholes situated between the old Return and Calcine boreholes (see Figure 4-7). There are, however, no indications that arsenic from these boreholes has moved beyond the smelter site. Elevated arsenic levels were not recorded at boreholes in the vicinity of the Hazardous Waste Disposal Site, indicating that the design of the site is sufficient to contain arsenic within the lined areas.

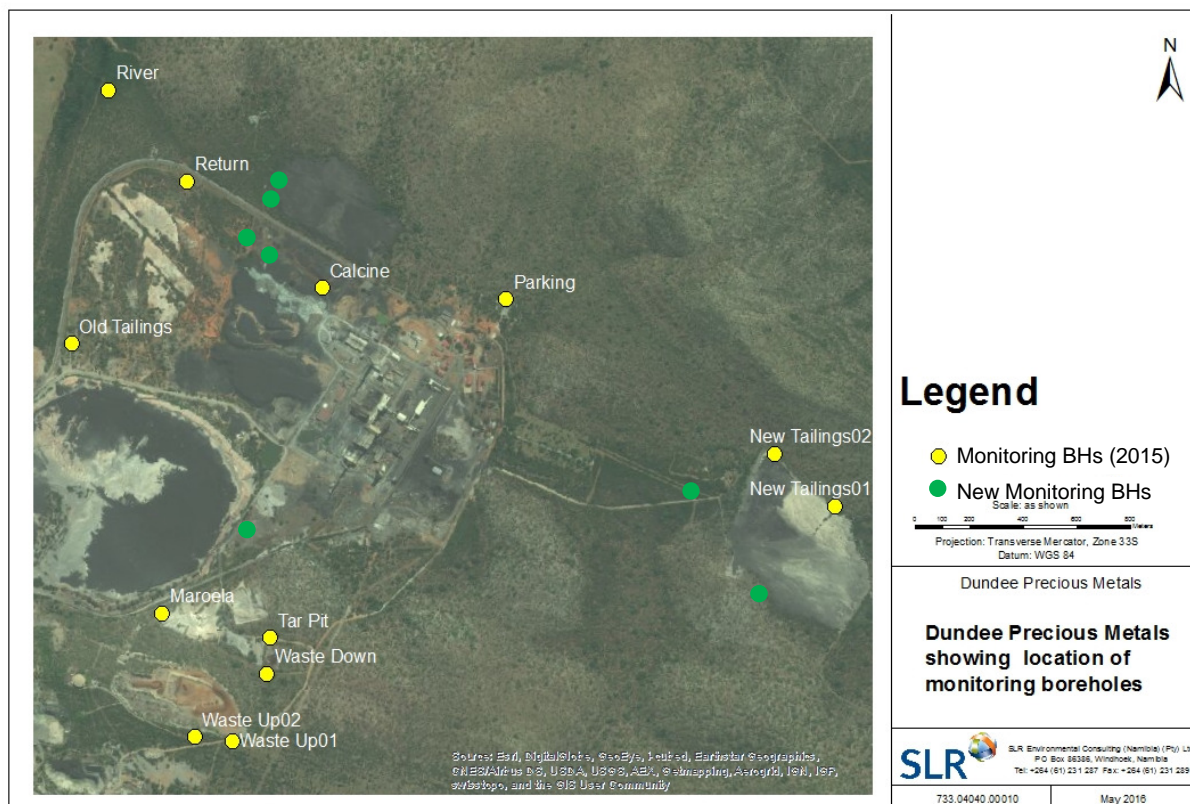


FIGURE 4-7: LOCATION OF GROUNDWATER MONITORING BOREHOLES WITHIN THE DPMT SITE

A predictive transport model was used to predict the risk of contaminating the groundwater of private groundwater users to the north of the smelter site by GCS (2016). The model predicted movement of the arsenic plume for the year 2038 and showed that the plume will continue to migrate north, with off-site boreholes closer to the DPMT site potentially experiencing arsenic concentrations higher than the Namibian drinking water limit of 0.3 mg/l. It was, however stated that there are uncertainties in this model and it is recommended as part of this ESIA process that the model be re-evaluated, taking into consideration the groundwater quality data from the Tsumeb Government Groundwater Study (GKW Consult / BICON 2003) and data from planned new monitoring boreholes to the north of the site.

4.4.4 GROUNDWATER USE

Tsumeb is highly dependent on groundwater resources (WSP Walmsley, 2004). Groundwater use in the area is as follows:

- The Tsumeb Municipality has a network of 39 boreholes which are used for domestic and industrial water supply.
- Several of the industries located to the north of the town have their own boreholes for water supply.
- Extensive agricultural activities occur immediately north of Tsumeb carrying out irrigation using groundwater resources.
- Agriculture to the south east of Tsumeb is also dependent on groundwater resources.

The agricultural, industrial and domestic demand for groundwater from the Tsumeb Aquifer has been estimated at 12 million m³ per annum (GKW Consult/Bicon, 2002). It is estimated that a surplus of 31 million m³ flows to the north.

DPMT currently abstract groundwater from the old No. 1 Shaft at an installed pumping capacity of about 300 m³/h for use at the smelter site (Worley Parsons, 2015). The requirement for an abstraction permit from the Ministry of Agriculture, Water and Forestry will be confirmed as part of this ESIA process and the relevant application submitted by DPMT, should it be required.

4.5 SURFACE WATER

4.5.1 REGIONAL HYDROLOGY

Tsumeb is located on the eastern side of the Etosha Basin catchment, which is an inland drainage system where runoff flows into the Etosha Pan from where it then evaporates. The area around Tsumeb is predominantly karstic, which means that it is formed from the dissolution of soluble base rock (mainly dolomite and limestone in this area) which is characterised by underground drainage systems with sink

holes and caves. Due to the geology of the area, there is no well-defined drainage pattern in the Tsumeb-Grootfontein area, but rather many small individual drainage systems, dependant on the local geology.

4.5.2 LOCAL HYDROLOGY

The local catchment can be divided up into an upper section (which included the old eastern Tailings Storage Facility (TSF) dam) covering an area of approximately 2.85 km² and the lower catchment below the TSF dam, which includes the main smelter and current western TSF areas, covering an area of 6.88 km², giving a total catchment area at the outlet on the border of the DPMT site boundary of 9.73 km².

To the west of the site is a drainage line (locally known as the Jordan River), which has its catchment area in the townlands of Tsumeb, flowing in a northerly direction along the western boundary of the site and then continuing off to the north where it reportedly disappears into the ground. The Jordan River is not a natural water course, relying on runoff from the central business area and the north eastern part of Tsumeb, but typically has only a low flow or is temporarily dry if there is no rainfall. There is some indication that a portion of the water pumped from Shaft 1 reaches the Jordan River, but this is not confirmed.

Within the lower catchment area are two small dams (Dam 10 [also called No. 10 Gate Dam] which contains decant water from the tailings dam plus return process water and Railway Dam which contains overflow from Dam 10). The local hydrology is indicated in Figure 4-8.

4.5.3 SURFACE WATER QUALITY

As there are no natural surface water sources on the site, open water sources on the site consist of manmade dams and concrete reservoirs fed by abstracted groundwater, and stormwater runoff during rain events. No historical surface water sample programme has been undertaken at site, but a monitoring programme is currently being set up which should start to provide baseline data for the site.

Surface water samples from storage dams and the Jordan River were collected in October 2015 by Groundwater Consulting Services at four locations within the site and one just outside the site at the Jordan River road crossing. Samples within the site were collected at the Railway Dam and Dam 10 (both open water surfaces) as well as from Large Reservoir and Small Reservoir (concrete elevated reservoirs) located on the southern watershed. The water which supplies the Large Reservoir is municipal water pumped from municipal boreholes to the south of Tsumeb, while the water supply to the Small Reservoir is raw water pumped from Shaft 1. Technically the samples from the Large and Small Reservoirs are classified as groundwater, having been pumped from boreholes. The results showed that the arsenic levels in all the surface water samples, except for the municipal borehole water, are above acceptable guideline levels for human consumption. The water quality from the municipal boreholes was found to be

at Group C level which indicates a low health risk (see Appendix E for a more detailed analysis of the results from this sampling).

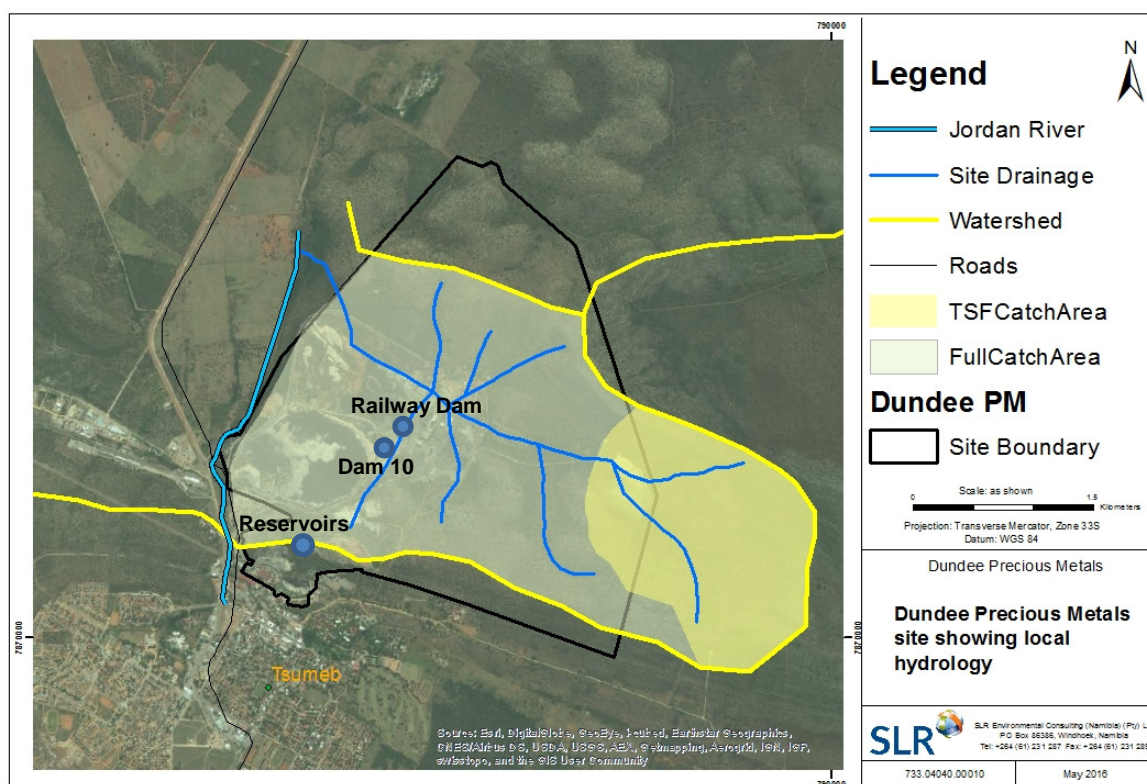


FIGURE 4-8: LOCAL HYDROLOGY OF THE DPMT SMELTER SITE

Apart from the arsenic contamination sources, an additional smaller surface water impact is generated from the wastewater effluent and sewerage currently temporarily being discharged to the reed beds on the site. DPMT held a valid exemption permit from the Ministry of Agriculture, Water and Forestry for discharging effluent and waste water to the reed bed area (expired on 31 March 2016) prior to the establishment of a formal sewage plant. DPMT now have a new sewage plant system in place, but due to unexpected oil contamination of the system, it is currently not operational, leading to temporary continuation of discharges to the reed beds. This matter is currently being addressed and the plant should be operational soon. As this was an unexpected disruption of plant operations, the permit renewal is still to take place.

With regards to stormwater drainage across the site, the system currently comprises two main drainage pipelines through the plant area which end in sumps, from where the runoff is pumped to various points inside the plant. Problems have been experienced with silting of the storm water system and some of the infrastructure is inadequate for the generated runoff, resulting in ponding of runoff at a number of identified sites around the plant after storm events. An updated stormwater management plan has, however, been compiled by Aurecon (2013) which includes recommendations for improvement of the system. The improved system includes the rehabilitation of the old eastern tailings storage facility and

historical slag area and establishment of pollution control dams and diversion channels. This system is currently being implemented in phases by DPMT.

There are no identified downstream users of surface water between the smelter site and the Jordan River, which has limited flow for a short distance downstream.

4.6 SOIL

A soil survey and mapping exercise of the DPMT property was undertaken by Red Earth cc (McLeroth, 2015) in 2015. The different soil types identified were grouped together into soil-mapping units on the basis of soil form, effective soil depth for rehabilitation (stripping depth) and cropping (effective rooting depth), surface features, parent material, perched water-table depth, location of precipitated salts associated with pollution plumes and overburden/underburden waste or non-waste type/depth where present (McLeroth, 2015). The different soils are indicated in Figure 4-9 and in Table 4-3. A short summary of the soil forms identified within the smelter boundary are provided below.

TABLE 4-3: SUMMARY OF SOIL FORMS (MCLEROTH, 2015)

Soils Summary								
Map Notation	Soil Form (South African Taxonomic System)	Soil Horizons	Broad Soil Group	Count	Area (ha)	Area (%)	Area (ha)	Area (%)
Hu	Hutton	orthic A/red apedal B/unspecified	Red apedal	110	136.98	14.24	147.65	15.35
Bv	Bainsvlei	orthic A/red apedal B/soft plinthic B		9	10.67	1.11		
Sd	Shortlands	orthic A/red structured B	Red structured	4	4.35	0.45	4.35	0.45
Bo	Bonheim	melanic A/pedocutanic B/unspecified	Structured (i.e. Pedocutanic)	2	1.88	0.20	13.50	1.40
Se	Sepane	orthic A/pedocutanic B/unconsolidated wet material		6	11.62	1.21		
Oa	Oakleaf	orthic A/neocutanic B/unspecified	Neocutanic	5	5.82	0.61	5.82	0.61
Ms	Mispah	orthic A/hard rock (note - the soil auger is unable to penetrate the underlying rock layers. Thus, despite the indicated Ms soil form, the Gs soil form will be equally dominant in these areas)	Shallow	116	458.90	47.72	497.65	51.75
Gs	Glenrosa	orthic A/lithocutanic B		22	38.75	4.03		
Py	Plooyburg	orthic A/red apedal B/hardpan carbonate horizon	Carbonate	10	3.18	0.33	20.03	2.08
Gm	Gamoep	orthic A/neocutanic B/hardpan carbonate horizon		3	4.41	0.46		
Pr	Prieska	orthic A/neocarbonate B/hardpan carbonate horizon		1	0.80	0.08		
Ag	Augrabies	orthic A/neocarbonate B/unspecified		2	3.66	0.38		
Mu	Montagu	orthic A/neocarbonate B/unspecified wet material		1	0.57	0.06		
Br	Bransvlei	orthic A/soft carbonate horizon		5	7.41	0.77		
We	Westleigh	orthic A/soft plinthic B	Hydromorphic	3	4.97	0.52	4.97	0.52
Wb	Witbank	orthic A/man-made 'soil' deposit	Man-made	35	45.40	4.72	45.40	4.72
Stream	'Stream' (natural)			2	0.75	0.08	2.15	0.22
Gully	Drainage 'Gully' (natural)			29	1.40	0.15		
SUB-TOTAL (SOILS)				365	741.52	77.11	741.52	77.11

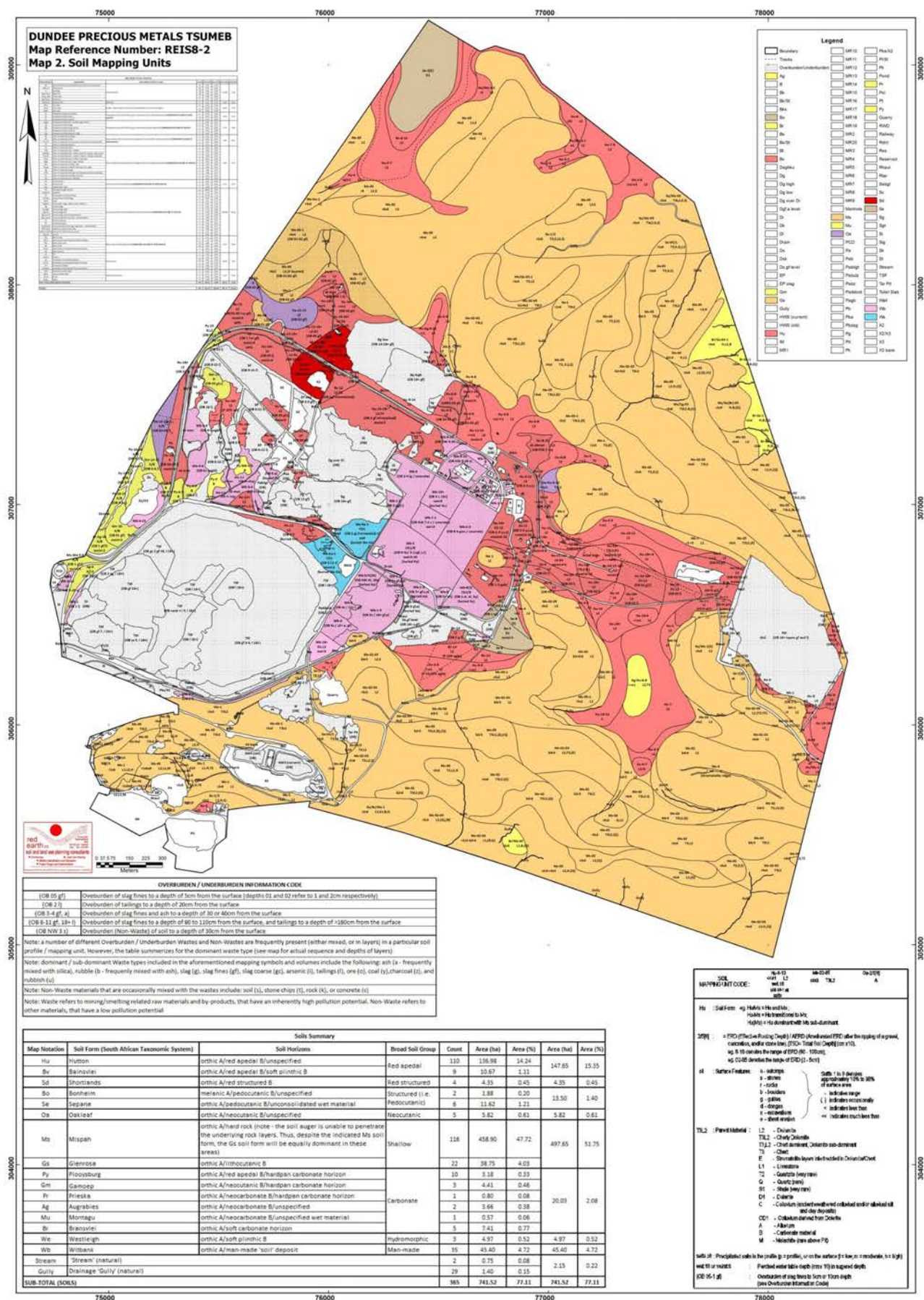


FIGURE 4-9: SOIL MAPPING UNITS RECORDED ON THE SMELTER PROPERTY (MCLEROTH, 2015)

The soils encountered in the study area can be divided into the following eight groups as described in McCleroth, 2015:

i) **Red apedal soils** (Hutton and Bainsvlei forms) [15.35 % of the study area]

These well drained deep to intermediate (vast majority >1.8 - 0.5m), or occasionally shallow (0.4 - 0.2m) soils occur in the 'flats' (very gently to gently sloping areas between the hills), the parent material underlying these areas being dolomite (vast majority), dolerite (narrow band trending west-north-west through the 'flats', and alluvium (narrow band east/upslope of the Jordan River).

In dolomite and alluvium derived areas textures are sandy-loam (clay percentage 14 - 16 %, or occasionally 12 % or 20 %) in the topsoil; and sandy-loam (clay percentage 14 - 20 %) in the subsoil. In dolerite derived areas textures are sandy-clay-loam (clay percentage 30 %) in the topsoil and sandy-clay-loam to clay (clay percentage 25 - 50 %) in the subsoil, all of the aforementioned being field estimates. The analytical data showed 9 - 11 % for the topsoils, and 12 - 13 % for the subsoils (two topsoils and two subsoils).

Soil structure is apedal in both horizons in the dolomite and alluvium derived areas; and weak blocky (occasionally apedal) in the dolerite derived areas. Sand grades are all fine.

These soils are poorly leached. The high quality orthic A- and red apedal B-horizons are highly suitable materials for annual cropping (good rooting medium) and use as topsoil (for rehabilitation purposes), having favourable texture (sandy-loam in dolomite derived areas, to sandy-clay-loam to clay in dolerite derived areas), structure (apedal in dolomite derived areas, to weak blocky in dolerite derived areas) and consistency (friable to slightly firm).

ii) **Red structured soils** (Shortlands form) [0.45 % of the study area]

These dolerite derived soils occur in one small patch only, and are surrounded by red apedal soils, to which they are similar. However, their properties vary in a number of ways. Textures are clay (clay percentage 40 - 50 % in dolerite derived areas) or sandy-clay-loam (clay percentage 20 - 25 % due to soil creep from surrounding red apedal areas) in the topsoil; and clay (clay percentage 50 - 60 % all dolerite derived) in the subsoil. Structure is weak blocky or apedal in the topsoil; and moderate blocky in the subsoil. These soils are poorly leached (eutrophic). The high quality orthic A- and red structured B-horizons are highly suitable materials for annual cropping (good rooting medium) and use as topsoil having a favourable texture (sandy-clay-loam to clay).

iii) **Neocutanic soils** (Oakleaf form) [0.61 % of the study area]

These relatively well drained, deep (>1.8 - 1.0m) soils predominantly occur in one band on the flood plain (eastern side) of the Jordan River. This area has been divided into two patches by the western boundary of the study area. This area is derived from alluvium parent material, with one connected patch being derived from dolomite colluvium. Textures are sandy-loam (clay percentage 14 - 20 %) or loamy-sand

(clay percentage 8 - 12 %) in the topsoil; and sandy-loam (clay percentage 12 -20 %) or sandy-clay-loam (clay percentage 20 - 30 %) in the subsoil.

These soils are essentially red apedal soils, the only difference being that they are non-uniform in colour due to the presence of cutans and channel infillings. One other small patch of neocutanic soils derived from dolomite colluvium occurs at the base of the hill to the east of the plant.

Structure is apedal or weak blocky in both horizons, while sand grades are medium (occasionally fine or coarse). A number of the topsoils are now slightly calcareous (transformed by man) due to the incorporation of washed tailings into the topsoil. The high quality orthic A- and neocutanic B-horizons of these soils are suitable materials for annual cropping and for use as topsoil, having favourable texture (loamy-sand to sandy-clay-loam), structure (apedal to weak blocky) and consistency (friable). However, these areas must not be disturbed since they are in riparian areas.

iv) **Carbonate soils** (Brandvlei, Gamoep, Augrabies, Plooyburg, Prieska, and Montagu forms) [2.08 % of the study area]

Carbonate soils (in McLeroth, 2015) include those soil profiles which display one or more of the following soil horizons: hardpan carbonate (dominant), soft carbonate (sub-dominant), or neocarbonate (rare). The effective rooting depth is dependent on the depth of the underlying hardpan carbonate horizon, soft carbonate horizon, hard rock, or unspecified material with signs of wetness.

These well drained moderate to deep (0.4 - 1.5m) soils predominantly occur in the vicinity (east) of the Jordan River, the majority of these areas being derived from alluvium, which in turn overlies calcrete. These soils are generally non-calcareous except in the A-horizon. Soil textures are sandy-loam (clay percentage 12 - 20 %) for both horizons, and occasionally sandy-clay-loam (clay percentage 25 - 35 %) in the subsoils. Soil structure is generally apedal for both horizons. Sand grade is medium or fine in the vicinity of the Jordan River and fine in the Brandvlei soil form areas. Two further patches of carbonate soils of the Brandvlei form occur in the hilly areas, these soils being shallow (0 - 0.1m) and overlying a soft carbonate horizon. These areas are derived from a dark coloured schist parent material, with occasional to frequent small quartz stones being present on the surface. These topsoils are highly calcareous. The generally high quality orthic A-, neocutanic B-, and neocarbonate B-horizons are suitable materials for use as 'topsoil', having favourable texture (sandy-loam to sandy-clay-loam), structure (apedal), and consistency (very friable to friable). However, the carbonate soils in the vicinity of the Jordan River should not be disturbed when they are derived from alluvium parent material, since these are in riparian areas.

v) **Structured (i.e. pedocutanic) soils** (Sepane and Bonheim forms) [1.40 % of the study area]

These poorly drained intermediate depth (0.5 - 0.8m) pedocutanic soils occur in two patches on base rich parent material (probably dolerite, although not observed in augered depth).

Textures are clay (clay percentage 50 - 60 %) in the topsoil, and clay (clay percentage 60 %) in the subsoil, the sand grades all being fine. Structure varies from weak to moderate blocky in the topsoil and

from moderate to strong angular blocky in the subsoil, while subsoil consistence (dry) is hard to very hard. The subsoils are eutrophic (poorly leached). The area at the northern corner of the study area is highly calcareous, while the southern area is only slightly calcareous. The pedocutanic subsoils are non-uniform in colour due to the presence of cutans (clay skins) on most ped surfaces, and both the presence of 2:1 clays and the high clay contents have given rise to the pedality (structure) of the soils.

The usable soil depth is dependent on the depth of the underlying unconsolidated material with signs of wetness, these areas (majority) being temporary wetlands. The poor quality orthic A-, melanic A- and pedocutanic B-horizons are unsuitable materials for rehabilitation topsoiling purposes, given their unfavourable properties.

The structured soil group material is useful (most suitable of all of the broad soil groups in the study area) for sealing purposes (underlying tailings/slimes dams, evaporation ponds, pollution control/return water dams, the dirty water gullies/drains/canals, and the slag/arsenic dumps; or overlying [as a compacted- 'remoulded' layer below the 'topsoil'] rehabilitated tailings/slimes dams, pollution control/return water dams or slag/arsenic dumps) since it naturally displays a slow-moderate permeability when dry, and a slow permeability once moist or compacted. Unfortunately, this material is in very short supply in the study area.

vi) **Shallow soils** (Mispah and Glenrosa forms) [51.75 % of the study area]

These shallow (0.02 - 0.1m majority, 0.2 - 0.3m minority) rocky (40 - 80 % surface rock in the form of rocks 5 - 50 cm diameter, boulders >50 cm diameter, outcrops = flat surface rock, and stones 2 - 5cm diameter) soils occur extensively in the hilly areas on a range of parent material types including cherty-dolomite, dolomite, chert, stromatolite inter-beds, limestone, schist, quartz (rare), and shale (very rare). The 'usable' soil depth is dependent on the depth of the underlying hard (vast majority Mispah form) or weathering (very rarely Glenrosa form) rock.

Textures are all sandy-loam (dominant clay percentage 14 - 16 %, occasionally 18 - 20 %, rarely 12 %), sand grades are fine (all), and soil structure is apedal (all). These soils are poorly leached (eutrophic), and approximately 45 % of the topsoils are calcareous (slightly, moderately, or highly) [extremely poorly leached, to not leached at all].

These areas are comprised of natural bush and must be preserved as repositories of biodiversity. Such areas are normally suited to game ranching, although this is not the case in the study area due to wind-blown pollution. These areas must not be disturbed in any way.

vii) **Hydromorphic soils** (Westleigh form) [0.52 % of the study area]. Also buried (by wastes and the 'western' tailings storage facility) Katspruit form (total buried area unknown)

The entirety of the hydromorphic soil area is buried beneath the southern two-thirds of the plant (Katspruit area), beneath an intermediate (0.5m) to thick (>1.8m) layer of overburden/underburden wastes (Witbank soil form overlying Katspruit soil form); and by the 'western' tailings storage facility. This originally concave valley-bottom slope position trends from the east to the west, but is now a level industrialized

area, unrecognizable as a wetland area from the surface. These areas are buried permanent (majority of buried area - buried Katspruit soil form) and seasonal (minority of buried area - buried Westleigh soil form) wetlands. The discussion which follows relates to the buried soils (not the overlying waste layers).

These poorly drained (frequently waterlogged in summer) hydromorphic soils display a clay texture (clay percentage 40 - 50 %) in the topsoil, and a clay texture (clay percentage 50 - 60 %) in the subsoil, these soils being derived from colluvium (probably of dolerite origin) and calcrete. These soils are highly calcareous, and particularly so in the subsoil. Soil structure varies from weak to moderate blocky in the topsoil, and from massive (G-horizon) to weak blocky (soft plinthic B-horizon) in the subsoil. Such soils have formed due to either a permanent/semi-permanent water-table (G-horizon - year round reduction), or a seasonal water-table (soft plinthic B - alternating cycles of oxidation and reduction accompanied by an accumulation of iron and manganese oxides). The poor quality (bleached and mottled, or dark) orthic A-horizons of this broad soil group may not be cropped, since these are wetland (permanent and seasonal) areas. These topsoils are not suitable for rehabilitation purposes. The majority of the buried hydromorphic soils were wet or moist at the time of the soil survey, thus displaying a perched water-table.

viii) **Man-made soils** (Witbank form) [4.72 % of the study area]

Man-made (i.e. anthropogenic) 'soils' occur in the developed (plant, associated auxiliary infrastructure, and lay-down areas) areas, as well as in six patches (fragmented into numerous patches by man-made features) to the north and west of the 'western' tailings storage facility. These areas either comprise *in-situ* soils (red apedal, hydromorphic, carbonate, and structured broad soil groups) that are buried by thick waste layers (most of the plant area, and the areas to the north and east of the 'western' tailings storage facility), or alternatively thick levelled waste layers that are buried by levelled topsoil of the red apedal (mostly) and/or hydromorphic broad soil groups (most of the lay-down area). These areas frequently display a number of alternating layers of soil, and occasionally wastes.

4.7 CONTAMINATED LAND

A study has been commissioned by DPMT to investigate the level of land contamination within and surrounding the Tsumeb smelter property. The study is designed to inform the required closure plan activities where it relates to land historically contaminated by chemicals of concern and where DPMT would be responsible for remediation. The study is still underway, but some preliminary results of soil sampling and related contamination levels have been made available for inclusion in this EIR. The below summary of preliminary results was taken from the draft Contaminated Land Assessment report compiled by the University of the Witwatersrand (Weiersbye, 2016).

The investigation is based on an intensive soil and waste survey on the greater Tsumeb mine area and smelter property and surrounding lands undertaken between 2014 and 2016. Soil sampling results were compared to similar soil sampling studies undertaken prior to 2007. The contaminated land assessment is being undertaken in three phases. Phase 1 has been completed and entailed mapping the spatial extent and depth of metal contamination on the smelter property. Phase 2, Part A entailed an

investigation into the soil leaching profiles of metals on the smelter property. Phase 2, Part B entailed the mapping of metal contamination off site in Tsumeb and along the Jordan River riparian zones and in the rooting zone of common edible plants and is still underway. Phase 3 will include a quantitative environmental risk assessment of the consumption of soil and edible plants. Preliminary results of Phases 1 and 2 are provided below.

Phase 1 – identification and spatial mapping of Contaminants of Concern on and off the DPMT site and depth profiling of contamination

In summary, soils comprise 721.41ha (75.02%), while man-made features comprise 240.23ha (24.98%), of the DPMT property survey area of 961.64ha (100%); the soils, and overburden/underburden wastes having been mapped through the smelter plant areas. An equivalent additional area was mapped to the south of the DPMT property over the municipality of Tsumeb and surrounding lands, and northwards along the Jordan canal and creek system.

The findings independently verify the results of previous pilot and research studies on arsenic, lead, copper, cadmium and other metal concentrations in topsoils in the Tsumeb general region around the smelter property, and provide more confidence in spatial distribution and depth profiling of contaminants for quantitative risk assessment and remediation measures. A comparison with the prior findings can assist in quantifying the additional contamination load since 2007. The previous pilot studies supported by the current findings, as far as soil metal concentrations and contaminant sources are concerned, were conducted between 2004 and 2007 (Kribeck *et al.*, 2004; Geological Survey of the Mines and Energy, 2005; 2011; Mapani *et al.*, undated unpublished report (circa 2007); Hasheela *et al.*, 2014; Ellmies *et al.*, 2015; Kribeck *et al.*, 2010; 2016).

The findings of the soil investigation indicate that there is moderate to severe contamination by hazardous metals on the DPMT property, off-site in the northern section of Tsumeb Municipality, and along the Jordan Creek riparian zone and projected smelter deposition zone towards Witvlei Farm. In some cases contamination is exceeding all international soil guideline values (SGVs) or trigger soil screening values (SSVs) or critical toxicity threshold levels. Lesser contamination (still exceeding some SGVs) is evident throughout most of the town of Tsumeb. Even when severe, contamination throughout the DPMT and off-site regions (including town of Tsumeb) tends to be shallow – largely limited to the upper 10 cm, or even 0-2 cm, of undisturbed soils, by 30 cm to 60 cm depth contamination has significantly declined or is non-evident. Exceptions are where soils are disturbed (dug, excavated, cultivated, relocated) or in seepage zones, and adjacent to canals, in which case contamination can reach 100 cm to 180 cm depths.

The investigation showed that the contamination emanates from four major sources:

- the historical smelter complex, in the form of deposition and run-off of contaminated soils to lower areas,
- the tailings storage facilities (TSFs) or “mine dumps”, in the form of wind-blown tailings dust, spillage or run-off, and sub-surface seepage from the toe and unlined canals,
- the calcine dam and arsenic plant, in the form of wind-blown dust, spillage or run-off, and sub-surface seepage from the toe and unlined canals, and
- the modern smelter, in the form of deposition and run-off of contaminated soils.

In addition to wind and rainfall run-off, significant contaminant loads are relocated by:

- burial or relocation of contaminated material on and around site,
- pollutant saturated wetland soils.
- subsurface seepage and surface run-off of tailings and particulates into creek sediments,
- unlined canals draining the plant area, and sediment transport

Additional contamination includes wind-blown and run-off of slag and tailings dust, in addition to historical spillages, which are impacting on the Jordan stream (artificially canalised) and riparian vegetation close to the property.

The Contaminants of Concern (CoC) identified on and off site, with surface concentrations of orders of magnitude greater than local geochemical backgrounds (i.e. primarily from mined ores and smelting) include: sulphur (S), arsenic (As), copper (Cu), chromium (Cr), cadmium (Cd), lead (Pb), antimony (Sb), vanadium (V) and zinc (Zn). Additional contaminants, of lesser or low concern, are cobalt (Co), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and tin (Sn). Mercury (Hg) contamination was expected, but was not detectable above 1 ppm. Further sensitive analysis of Hg levels is still to be undertaken.

The median values for the main contaminants of concern in the 0-2 cm soil layers of the DPMT property as a whole (almost 1000 ha surveyed on-site) were 266 mg/kg As, 829 mg/kg Cu, 28 mg/kg Cd, 1 139 mg/kg Pb and 21 mg/kg Sb, with maxima of 6 315 mg/kg As, 28 950 mg/kg Cu, 2 105 mg/kg Cd, 31 140 mg/kg Pb and 3 760 mg/kg Sb in some deposition zones and localised contaminated areas.

The median values for the surveyed off-site area (the entire town of Tsumeb and surrounds) were 44 mg/kg As, 161 mg/kg Cu, 3 mg/kg Cd, 229 mg/kg Pb and 9 mg/kg Sb in the 0-2 cm soil layers, with maxima of 1 829 mg/kg As, 10 810 mg/kg Cu, 139 mg/kg Cd, 8 146 mg/kg Pb and 179 mg/kg Sb. All the higher soil metal values were localised in the northern section of Tsumeb Municipality, abutting the historical smelter site, the derelict mining infrastructure and the DPMT property boundary with the modern smelter infrastructure and tailings dams. Elevated metal concentrations were also evident off-site along the riparian soils of the Jordan creek system.

Soil pH ranges from +/- pH 6 to +/- pH 8 across most of the site with localised areas of lowest pH between +/- pH 5 to 6 around the arsenic calcine dam area and in some buried wastes and tailings spillages or seepage. Contamination is largely limited to the undisturbed surface soil layers (0-2 cm and 0-30 cm) across most of the DPMT property and off-site, except where there is evidence for acidic seepage and run-off. Metal mobility is strongly influenced by pH. The deposition and seepage of sulphates has resulted in some degree of soil acidification across the site. Although the acidity is buffered by the presence of free lime in the soils, the drop in pH of 1-3 units can have a significant impact on the mobility of some of the CoCs, increasing cadmium (Cd) leaching in particular and thus the risk of shallow groundwater pollution. Further drops in pH on this site could be extremely harmful, increasing the mobility of most (not all) CoCs. . Since even marginal declines in soil pH represent significant acidification, resulting in breakthrough leaching to deeper soil and potentially groundwater of pH-labile metals such as Cd, all areas around waste and tailings with pH of <7.0 are of priority for remediation.

Due to the natural topography, the distribution of CoCs to the north, east and south over the town of Tsumeb is however limited. Significant contamination of Tsumeb is localised to the northern section and appears to have emanated from the historical smelter and mining operations, overlain by the modern smelter impact. The main dispersion area of significant contamination from the DPMT property is off-site to the west, northwest and southwest, and appears to extend off-site at medium to severe levels (depending upon CoC) for at least 20 km to the northwest and 20 km to the west.

The measured CoCs were spatially mapped to show distribution and depth of contamination. One of the maps showing the combined distribution of arsenic, cadmium, copper, lead and antimony in all surface materials on the smelter property, Tsumeb town and surrounding lands is provided in Figure 4-10.

Sampling results showed that there is moderate to severe contamination by hazardous metals and metalloids in places that emanates from the following major primary sources:

- the historical smelter emissions, in the form of deposition and run-off of contaminated soils to lower areas;
- the TSFs, in the form of wind-blown tailings dust, spillage or run-off, and seepage;
- the calcine and baghouse dust arsenic stockpile;
- old waste heaps, some on surface, some buried, including tar pits;
- the modern smelter, in the form of deposition and run-off of contaminated soils, and burial or relocation of contaminated material by personnel; and
- additional, less toxic but still hazardous contamination from slag dust which coats vegetation, smothering and killing it, and may impact on the respiratory health of humans and other animals.

Secondary sources of contamination include:

- run-off of trapped smelter particulates from higher-lying areas (i.e. the surrounding hill-crests) to lower on the soil slopes;
- spilled tailings;
- contaminated sediments of the Jordan River draining Tsumeb and the smelter property in areas where no pollution control barriers exist;
- wetland sediments on-site and off-site;
- seepage of polluted run-off into the underlying soils of the plant area;
- heaps of old metallurgical plant refuse on non-bunded areas, including assay crucibles;
- concentrations of unknown origin in the plant area;
- relocation of contaminated soil for levelling purposes in the laydown areas;
- road dust transported on vehicle tyres into Tsumeb and other areas; and
- fugitive dust trapped on buildings, and wash-off.

In summary, despite the sometimes exceptionally high concentrations of CoCs recorded, the depth of contamination of soil and sediments was found to be superficial over most of the DPMT site and the Municipality of Tsumeb, with contamination levels declining rapidly with soil sampling depth. Where soils are undisturbed the leaching of contaminants to deeper profiles were found to be extremely limited. Exceptions are areas of seepage, and deeper soil disturbance (e.g. construction, man-made soil platforms, ploughing, rubbish tips, tarpits etc), and zones of soil acidification where soil pH is below pH 6.4.

Phase 2 – preliminary results of contaminant depth profiling and seasonal mobility

a) In situ rain-water leaching profiles:

A comparison of the dry season and wet season soil samples and profiles clearly shows which soils types facilitate the re-mobilisation of CoCs during wet and dry periods. During the rainy season, such CoCs move down the soil profile with the wetting front, and during the dry season they move up the soil profile due to the evaporation gradient. CoCs and sulphates precipitate as secondary efflorescence minerals in the uppermost topsoils and as mineral-rich crusts. If properly timed, this seasonal drying and concentration of minerals in shallow soil depths at high concentrations facilitates sweeping or mechanical skimming-off of a significant amount of contaminated material without the need for deeper soil excavation. The re-mobilisation of metals in these crusts is expected to be high, and is currently under assessment.

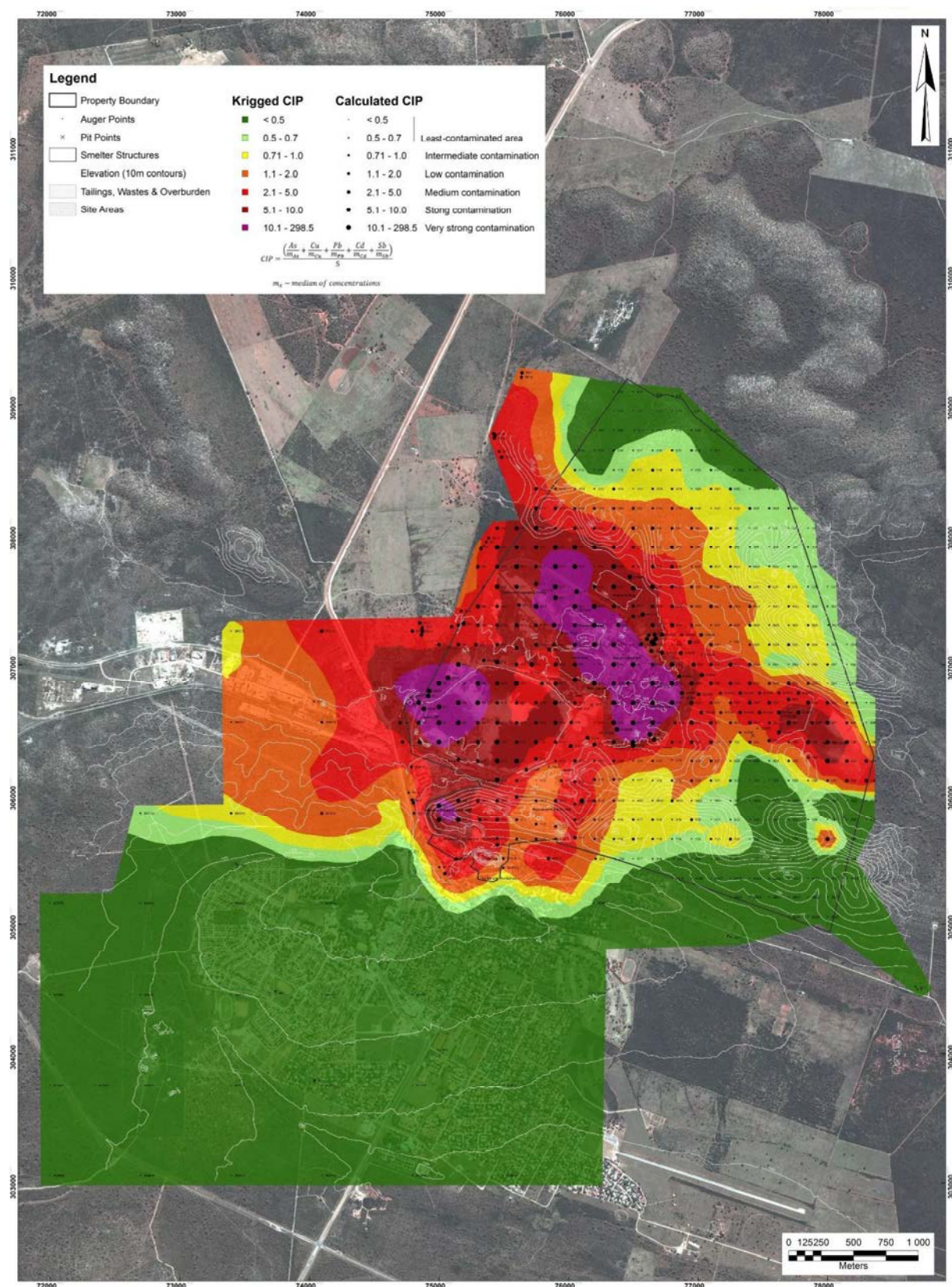


FIGURE 4-10: INDEX OF INDUSTRIAL POLLUTION (CIP) FOR As, Cd, Cu, Pb AND Sb IN ALL SURFACE MATERIALS COMBINED. TAILINGS, WASTES, OVERBURDEN AND STOCKPILES ARE SHOWN FOR THE 0-30 CM DEPTH, AND SURROUNDING (I.E. NO OVERBURDEN) SOILS FOR 0-2 CM DEPTH.

Based on wet season soil pit profiles, Cd, As and Zn exhibited some vertical leaching in more acidic profiles. In contrast, clayey soil types and areas with higher levels of soil organic matter (SOM), such as the riparian zones of the Jordan stream canal and wetland areas on-site exhibit little to no vertical migration of CoCs, although the canal itself acts as a major conduit of contamination off-site from the smelter property.

b) Additional sampling of hazardous waste on the DPMT site:

Additional sampling continued to verify anthropogenic activities on-site (primarily smelting, waste disposal and uncovered tailings) as the source of local and regional contamination (historical and modern smelting activities). No additional contamination over-and-above the local levels (already elevated) from the hazardous waste disposal site were recorded. Up to the end of sampling in mid-2016 the hazardous waste disposal site thus appears well contained on the land surface.

c) Evidence of contamination outside of smelter boundary

There is evidence for diffuse contamination, exceeding some international soil guideline values (SGVs) for agricultural, residential and commercial land, across the entire Tsumeb area assessed, even allowing for the natural elevation of base metals and arsenic in the soils of this locality. Severe contamination across the town of Tsumeb is however largely limited to the northernmost area, and is clearly of smelter and tailings dust/mining origin.

Although there are historical / anecdotal records for a mined-out copper “mountain” having been present within the current town of Tsumeb, no geochemical evidence was found (e.g. elevated copper signatures) that could delineate its location within Tsumeb at the sampling grid used (750 x 750 m). Contamination over Tsumeb is significantly linearly correlated with distance from the historic smelter and modern smelter in a southerly direction, and not with the presence of any remnant or residue contamination from any ore body once present in the town at the sampling grid used.

d) Contamination of drainage lines and water-courses.

All drainage lines on the DPMT and surrounding properties act as centres and conduits for CoCs to leave the property and enter the Jordan River. Unlined drainage canals are further contributing to significant contamination of deeper soils. The Jordan River is a seasonal drainage system, which was canalised at some point in history for part or all of its length and has an unnaturally linear course until it disperses in a wetland. The Jordan receives Tsumeb town run-off, DPMT site run-off, historical tailings spills, current tailings run-off and dust, sewage farm overflow and seasonal flood waters. The Jordan does not enter any other watercourses, but courses through Merdestroom Farm (Witvlei) and discharges diffusely into agricultural lands and a vlei area on Witvlei and the neighbouring farm. Due to the degraded nature of this area, the waters will drain into the groundwater system. Of concern is the presence of agricultural crops (including pivots) in the Jordan discharge zone. This will be further investigated as part of the ongoing contaminated land assessment.

Conclusion

There are significant contamination levels on the smelter property and surrounds due to historic mining and smelter operations and legacy waste stockpiles. Although it is acknowledged that the current DPMT smelter operations, since DPMT purchased the facility in 2010, have contributed to and continue to contribute to the overall contamination load, the majority of the measured contamination levels are attributable to historic operations. The ongoing Contaminated Land Assessment will aim to quantify the historic and current contributions.

Based on the preliminary results, some recommendations have been made for remediation measures for inclusion in the overall smelter Closure Plan. Some of the recommendations for remediation have also been included in the Consolidated EMP (see Appendix K). These largely relate to the process of phytoremediation, a process whereby vegetation is established on contaminated areas in order to extract contaminants from the soil and to assist in limiting seepage of pollutants into the deeper soil layers. Results show that the pollution footprint is already shrinking in the vicinity of the plant/waste sites due to the revamp (new construction/clean-up) which commenced when DPM purchased the smelter operation. The pollution plume is likely to further shrink after the establishment of indigenous trees as proposed in the contaminated land assessment. Phytoremediation 'woodlands' will serve (due to evapo-transpiration) to both limit the seepage of pollutants downwards to the perched- and ground- water-tables, as well as to limit seepage/run-off to the Jordan River. A phytoremediation report is currently being finalised which would provide further details of this process and the appropriate species to be established.

Other preliminary recommendations include the removal of the top 5 cm of surface crust of contaminated soils in the dry season, excavation of contaminated overburden waste layers and disposal to the tailings storage facilities and capping of the tailings facilities in preparation for the establishment of vegetation.

The study also supports the recommendations of previous studies for the cessation of agricultural production in the northern part of Tsumeb town (Ondundu) towards the smelter and to also restrict further development in this area, with development rather directed towards the southern and southwestern areas of the town where the least contamination was recorded. In addition to the above measures, the study also recommended that phytoremediation of soils in the residential areas be undertaken in collaboration with local schools and residents and that awareness programmes be established to educate poorer and more vulnerable population sectors in measures such as avoiding ingestion of soils, washing hands and food before eating, peeling fruit and vegetables, etc.

4.7 AIR QUALITY

The DPMT smelter is the main industrial source of air pollution in the Tsumeb area. An environmental monitoring network is in operation around the smelter complex. PM₁₀, trace metals (i.e. arsenic, lead and cadmium) and SO₂ ground level concentrations are measured on a daily basis (every ten minutes) and

reported on monthly and quarterly. Dust fall and the associated trace metal fallout are also sampled, forming part of the quarterly environmental report.

Figure 4-11 shows the location of the current monitoring locations and Air Quality Sensitive Receptors (AQSRs). The Plant Hill station is situated next to the Hazardous Waste Disposal Site along the southern boundary. Data from this station can be used to determine emissions from the waste site (as well as other sources) and to determine whether dust controls are adequate at the waste site. The Sewerage Works station is situated on the western boundary of the site and downwind of the dominant wind direction. Data from this station can be used to determine emissions from the Smelter site at large and to determine whether dust controls are adequate at the various fugitive and point emission sources on the site. Fugitive emissions refer to all air emission sources not released from stacks, e.g. from unpaved roads, crushing activities, furnaces, etc.

As the Namibian Atmospheric Pollution Prevention Ordinance (No. 11 of 1976) does not include any ambient air standards, the limits as stipulated in the South African National Ambient Air Quality Standards (SA NAAQS) is used in the below baseline air quality information.

4.8.1 AMBIENT PM₁₀ CONCENTRATIONS

During the period January 2013 to October 2016 (see Table 4-4) annual average PM₁₀ concentrations varied between 19.4 µg/m³ and 91.7 µg/m³. Exceedances of the annual average limit of 40 µg/m³ (SA NAAQS) were recorded at Namfo, the Sewerage Works and the Sport Stadium monitoring stations. 24-hour concentrations exceeded short term assessment criteria (4 days of exceedance of 75 µg/m³ permitted per year in terms of SA NAAQS and WHO) at all five stations over the four year monitoring period. The Plant Hill station showed the lowest PM₁₀ concentrations and least exceedances of the 24-hour limit. The station at the Sport Stadium recorded the highest number of exceedances of the 24-hour limit. It is to be noted that the ambient monitoring station at the Sport Stadium is in a residential neighbourhood with unpaved roads and heavy traffic and is located about 4 km from the smelter with other residential and industrial areas in between.

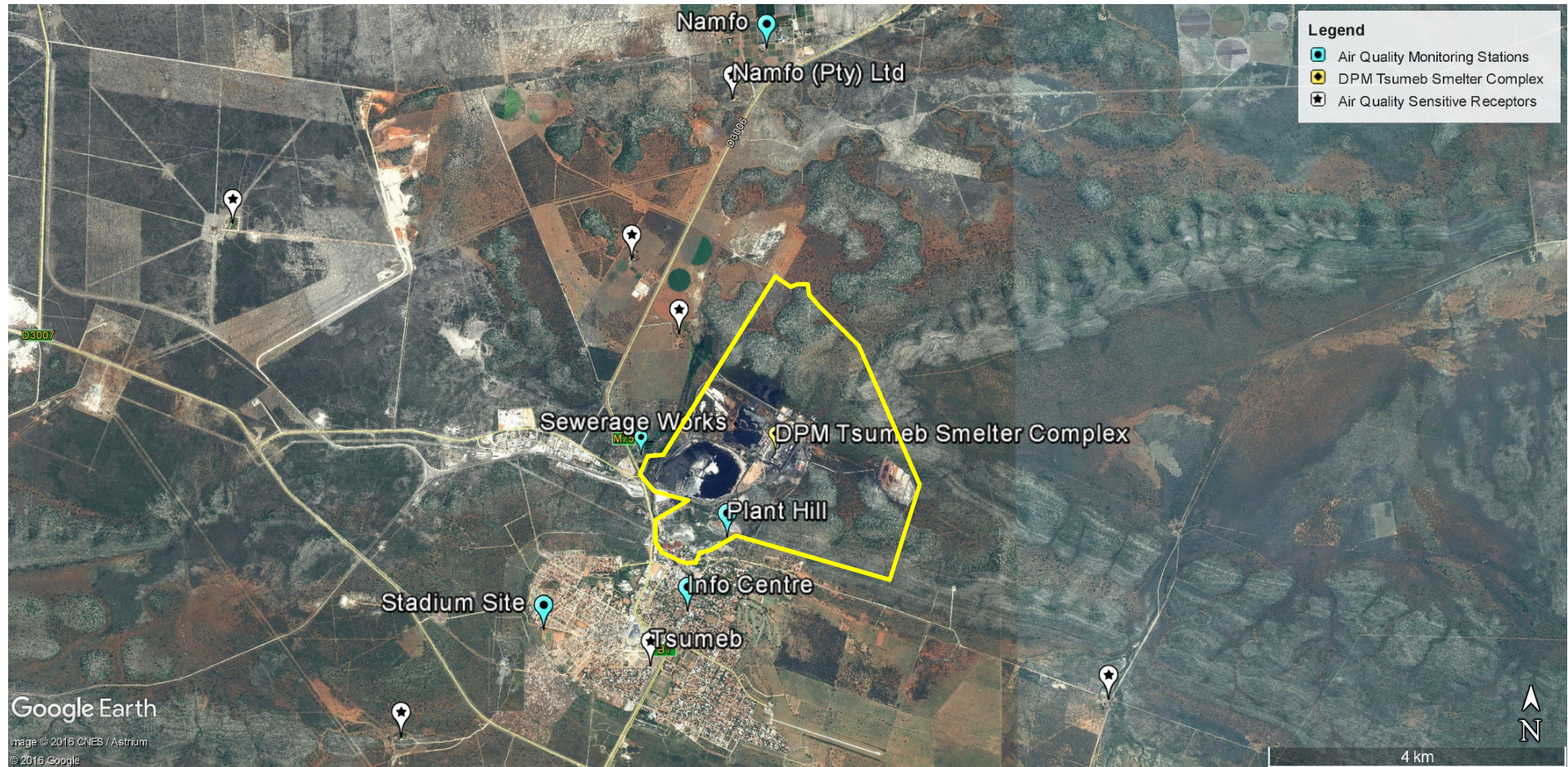


FIGURE 4-11: AIR QUALITY MONITORING SITES AND AIR QUALITY SENSITIVE RECEPTORS

TABLE 4-4: SUMMARY OF PM₁₀ MONITORING DATA AT THE DPMT MONITORING STATIONS (JANUARY 2013 – OCTOBER 2016)

Pollutant		PM ₁₀ concentration (µg/m ³) – Limit = 40 µg/m ³				
	Station Name	Info Centre	Namfo	Plant Hill	Sewerage Works	Sport Stadium
Annual Average						
Year	2013	32.4	32.8	29.8	91.7	62.6
	2014	30.7	70.4	19.4	74.2	55.5
	2015	33.6	44.6	32.5	42.2	65
	2016	37.2	23	20.2	41.2	29.3
Days of exceedance of 24-hour limit for PM₁₀ – Limit = 4						
Year	2013	10	9	14	30	154
	2014	7	117	1	52	122
	2015	16	16	17	47	145
	2016	19	1	0	31	0

An analysis of the observed PM₁₀ concentrations at the monitoring stations was completed, in which the concentration values have been categorised into wind speed and direction bins for different concentrations. This information is most easily visualised as polar plots (Ropkins & Carslaw, 2012). The polar plots provide an indication of the directional contribution as well as the dependence of concentrations on wind speed. These are provided in Figure 4-12 for the Plant Hill and Sewerage Works stations. The polar plot for Plant Hill shows two notable sources of PM₁₀, one to the north-east and one in a southerly to south-westerly direction. Although peak concentrations in data can be attributed to these sources, there are several sources of PM₁₀ in and around the Plant Hill site. Peaks in PM₁₀ levels recorded at the Sewerage Works station can be attributed to a source lying south-east of the station and under strong wind conditions. The active tailings dam area is a likely source.

The high PM₁₀ concentrations recorded at the Sport Stadium station likely result from the open area in the centre of town and an old open-cast pit to the south-west. There are also unpaved roads, undeveloped erven and the natural environment in the vicinity of the stadium.

High PM₁₀ concentrations were recorded from all wind directions, especially under incidences of high wind speeds. The stations located in Tsumeb – Information Centre, Plant Hill and Sport Stadium – all indicate the main contributing PM₁₀ sources not to be from DPMT whereas the Sewerage Works station, located downwind from the smelter, reflects activities and sources associated with the DPMT operations. PM₁₀ monthly mean concentrations per monitoring stations for the period 2013 to 2015 are depicted in Figure 4-13.

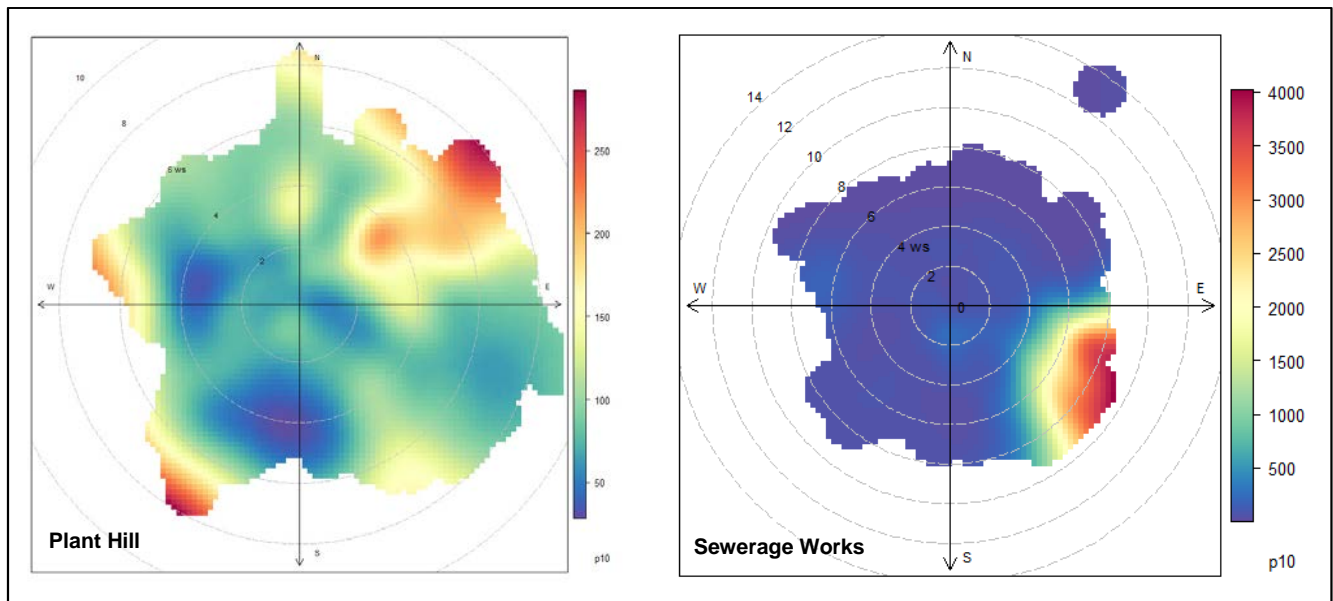


FIGURE 4-12: POLAR PLOT OF MAXIMUM HOURLY PM₁₀ (µg/m³) CONCENTRATIONS (JAN13-OCT16)

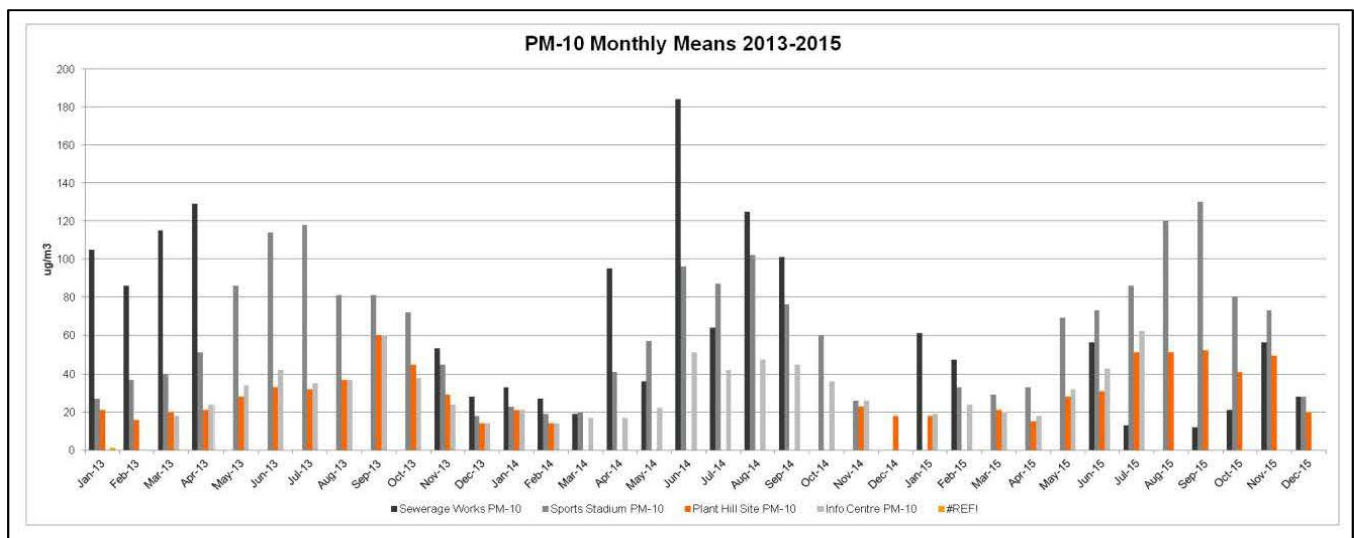


FIGURE 4-13: MEAN MONTHLY PM₁₀ LEVELS RECORDED AT TSUMEB SMELTER MONITORING SITES BETWEEN 2013 AND 2015 (DPMT, 2015)

4.8.2 AMBIENT ARSENIC CONCENTRATIONS

Arsenic in the PM₁₀ fraction is reported at all five ambient air quality stations. The following long term trends were reported for the 2012 to 2016 period (Winnaar, 2017):

- At the Sewerage Works, annual mean arsenic concentrations varied between approximately 0.25 µg/m³ and 2.75 µg/m³. The maximum of just over 2.75 µg/m³ was recorded in 2014. A notable decrease in annual average arsenic concentrations occurred in 2015 and 2016 with the minimum of 0.25 µg/m³ occurring in 2016.

- At Plant Hill, a maximum annual average arsenic concentration of $1.5 \mu\text{g}/\text{m}^3$ was recorded in 2014. For the base year of this assessment, 2016, the annual average concentration was between 0.2 and $0.3 \mu\text{g}/\text{m}^3$.
- Arsenic levels at the Sports Stadium show a decrease from just under $0.5 \mu\text{g}/\text{m}^3$ in 2013 to approximately $0.1 \mu\text{g}/\text{m}^3$ in 2016.
- Average ambient arsenic levels at the Info Centre site are the lowest. Since 2013, the annual mean concentration has decreased from approximately $0.25 \mu\text{g}/\text{m}^3$ to less than $0.1 \mu\text{g}/\text{m}^3$ in 2016.

The results clearly show higher ambient arsenic levels during dry and windy months. This would indicate fugitive dust from current activities and historic wastes rather than stack emissions from the smelter as the cause of elevated arsenic concentrations.

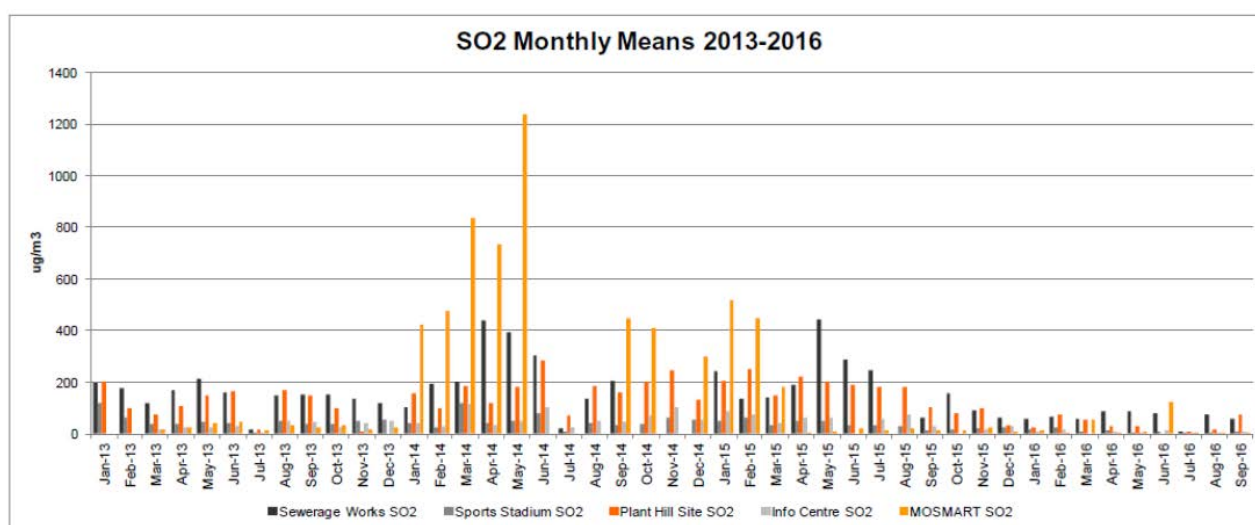
4.8.3 SULPHUR DIOXIDE

Air quality monitoring stations commissioned in 2012 showed that maximum daily concentrations of SO_2 emissions from the DPMT smelter exceeded the WHO daily guideline and South African standard for every month of the monitoring period (Golder, 2013). This led to the decision by DPMT to construct and commission a 1,540 t/d sulphuric acid plant in 2015 in order to reduce SO_2 emissions and improve local and regional ambient air quality. The acid plant was commissioned during June 2015. Air quality stations have reported downward trends of SO_2 emissions from October 2015 to September 2016 with the sulphuric acid plant being a major contributing factor. 122 000 tonnes of sulphuric acid was produced from January 2016 to September 2016, resulting in approximately 78 000 tonnes of SO_2 captured. No limits exist for SO_2 emissions in Namibian environmental legislation. Levels are thus evaluated by DPMT against best practice guidelines of $125 \mu\text{g}/\text{m}^3$ over a 24-hour period. The average annual SO_2 levels measured at the air quality monitoring stations are indicated in Table 4-5 and average monthly levels in Figure 4-14. A notable decrease is observed in 2016 levels with the only exceedance recorded at the Sewerage Works station.

During 2016 (after commissioning of the sulphuric acid plant), annual average SO_2 levels varied between $9.41 \mu\text{g}/\text{m}^3$ and $60.2 \mu\text{g}/\text{m}^3$ across the monitoring stations ($50 \mu\text{g}/\text{m}^3$ limit). When considering the shorter term averages, notable decreases in 24-hour and 1-hour concentrations are evident. Short term assessment criteria were, however, still exceeded at the Plant Hill and Sewerage Works stations, with a slight exceedance at the Namfo station.

TABLE 4-5: SUMMARY OF SO₂ MONITORING DATA AT THE DPMT MONITORING STATIONS (JANUARY 2013 – OCTOBER 2016)

	Pollutant	SO ₂ concentration (µg/m ³) – Limit = 50 µg/m ³				
	Station Name	Info Centre	Namfo	Plant Hill	Sewerage Works	Sport Stadium
Annual Average						
Year	2013	32.1	28.2	123	162	48.5
	2014	59.5	667	168	206	51
	2015	50	99.6	154	188	34.6
	2016	9.41	17.9	39.8	60.2	11
Days of exceedance of 24-hour limit for SO₂ – Limit = 4						
Year	2013	14	11	105	138	39
	2014	63	238	127	157	46
	2015	42	54	130	154	22
	2016	1	7	22	44	1

**FIGURE 4-14: MEAN MONTHLY SO₂ LEVELS RECORDED AT TSUMEB SMELTER MONITORING SITES FROM 2013 TO 2016 (DPMT, 2016)**

Polar plots of data from the Plant Hill station indicate a large SO₂ source (smelter) to the north-east of the station (see Figure 4-15). The data indicate that maximums occur just after midday when the atmosphere is likely to be unstable. It is known that the highest impact of elevated releases (tall stacks) occurs during unstable atmospheric conditions. Similarly, Sewerage Works data indicate a large SO₂ source in an easterly direction from the station (see Figure 4-15).

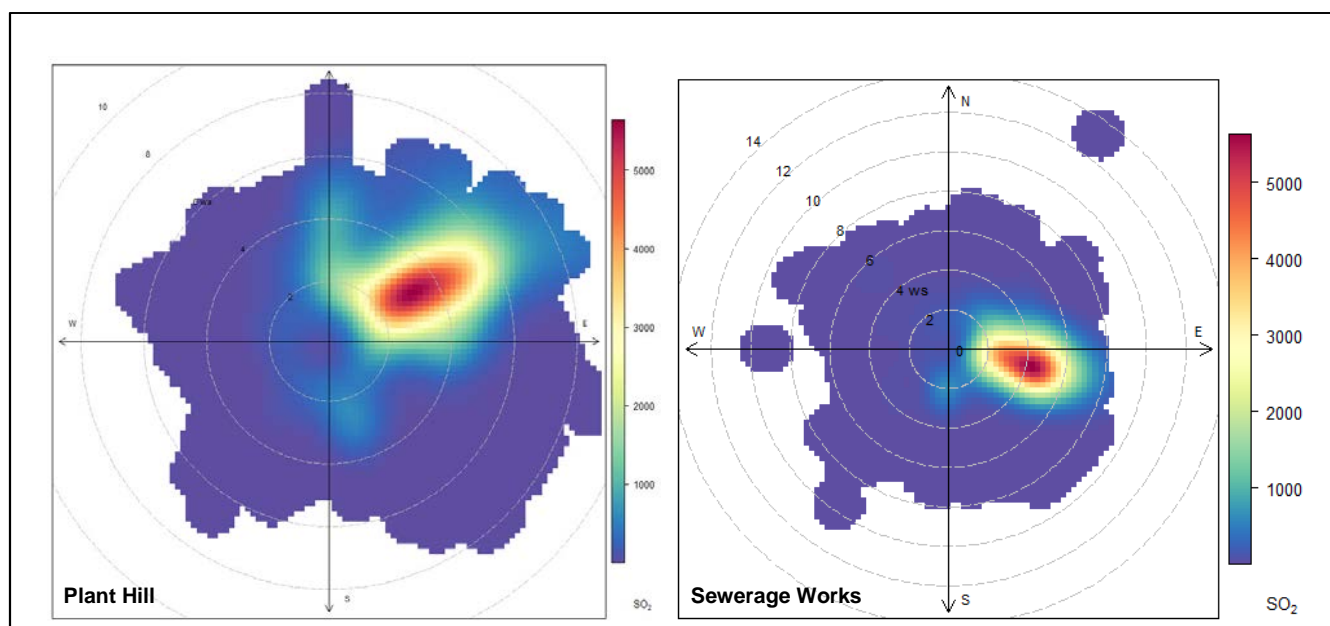


FIGURE 4-15: POLAR PLOT OF MAXIMUM HOURLY SO₂ (µg/m³) CONCENTRATIONS (JAN13-OCT16)

4.9 NOISE

The noise levels around the project area are influenced by traffic as well as the various construction and operational activities (e.g. blowers, trains, etc.) at the DPMT smelter. To monitor and manage noise control for employees within the smelter facility, DPMT undertakes monthly personal noise exposure measurements. Results of measurements show that within noise zones, most exposures exceed the statutory 85 dBA limit, including most production areas and the power plant. Suitable hearing protective devices are provided to employees and engineering controls to lower noise exposures have been identified. Installation of noise screens at the power plant commenced in the third quarter of 2016, resulting in a marked improvement in exposures.

The closest noise sensitive receivers outside of the smelter footprint include Tsumeb town and farmsteads. The atmospheric conditions in the area are found to be more conducive to noise attenuation during the day, with noise impacts from smelter activities expected to be most notable to the north-west and south of the smelter. The natural hill between the smelter and the town provides some acoustic shielding to residents of Tsumeb and its suburbs. A baseline assessment of noise levels in the area found that current operational activities at the smelter complex are only faintly audible at the closest farmsteads to the northwest of the smelter. Community activities, traffic, domestic animals, birds and insects were found to be the main contributors to the acoustic climate of Tsumeb and its suburbs. Current ambient noise levels at the closest noise sensitive receivers were measured at 44.8 dBA during the day and 39.4 dBA during the night. These levels do not currently exceed the IFC noise level guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night).

The No. 2 oxygen plant at the smelter currently generates high noise levels during its start-up cycle. At 27 m from the plant exhaust, which is located along the north-facing wall of the plant, a noise level of 99.7 dBA was recorded. This would imply a sound power or emission level of 136 dBA. It is understood that start-up noise levels persist for 30 minutes to an hour and that the oxygen plant starts up before the rest of the smelter complex to ensure sufficient oxygen supply. The silencer was not working as per specification during the noise specialist assessment, due to changes to the system to improve pressure regulation within the plant. This matter is currently being addressed.

4.10 VISUAL

The town of Tsumeb developed as a result of the mining and smelting operations and as such the Tsumeb Mine and Smelter are an integral part of the town's character. Despite the closure of the mine the De Wet Shaft head gear, located on the western edge of the CBD, has been retained as a constant reminder of the history of the town.

The Tsumeb Smelter and the closed mine and associated plant and infrastructure form a complex of heavily developed and industrialised areas. There are numerous large buildings and structures, rock and waste dumps and excavations that contribute to the mining atmosphere. While much of the smelter is concealed from the town of Tsumeb by the low ridge to the north of the town, the stacks are visible from most areas within the town and form an important component of the Tsumeb horizon. The hazardous waste site is visible from the Tsintsabis Road.

All the proposed new project components would be constructed within the existing facility footprint with no additional natural areas to be cleared or new visual intrusions to be created.

4.11 ARCHAEOLOGY AND CULTURAL HERITAGE

A few sites of archaeological and cultural heritage importance are located within the Tsumeb Smelter boundary fence. These include two stone kraal ruin sites (i.e. informal settlement) located in the hilly areas. The structures are older than 100 years. One possible stone-age stone core have also been recorded in the higher lying area (Red Earth, 2016). Two contemporary house ruin sites and twenty mining related ruin sites also occur within the Smelter property (Red Earth, 2016). None of the sites of heritage significance would be affected by the proposed upgrade and optimisation project.

4.12 BIODIVERSITY

4.12.1 VEGETATION

Tsumeb falls within the arid Savanna Biome (Harrison *et al.*, 1997) and the vegetation in the Tsumeb area can broadly be classified as Dolomite Karstveld (Burke *et al.*, in press). Due to the comparatively high rainfall and unique dolomite lithology of the area, it is recognised as a centre of plant species diversity in Namibia (Maggs *et al.*, 1998).

A biodiversity assessment completed in December 2016 (Van Zyl, *et al.*, 2016) identified four habitat types within the smelter boundary (see Figure 4-16). These include dolomite hills, sandy plains, alien infested plain and drainage line and the active smelter plant facilities and existing tailings area. Of these, only the dolomite hills and sandy plains are still considered as natural, albeit already altered to some extent.

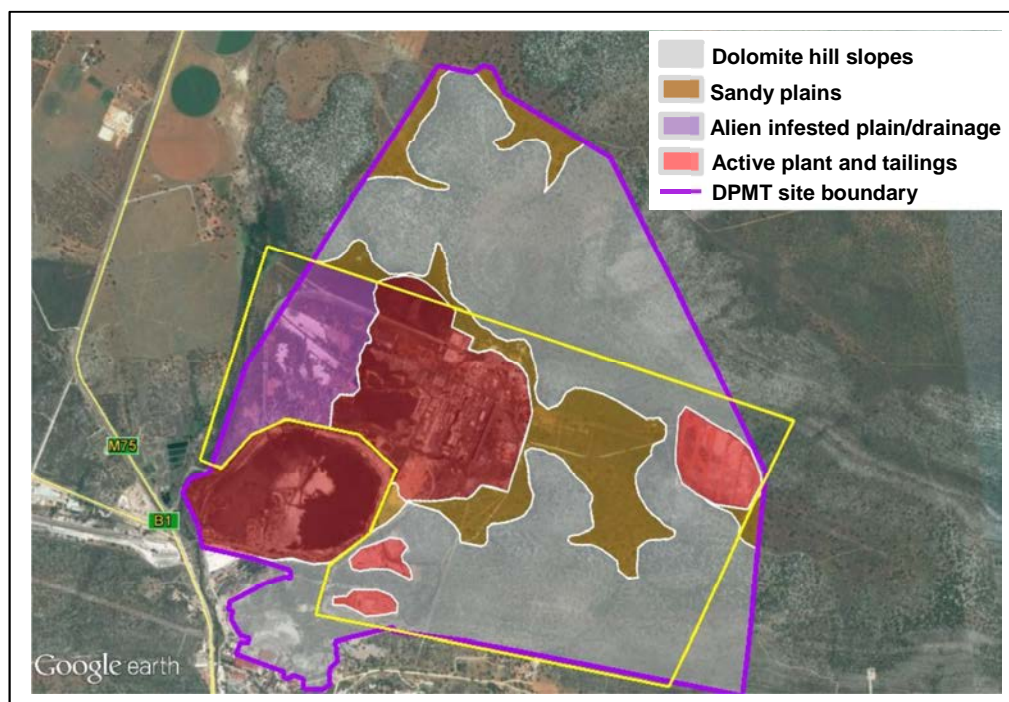


FIGURE 4-16: MAP OF HABITAT TYPES IDENTIFIED WITHIN THE SMELTER BOUNDARY (VAN ZYL *et al.*, 2016). (YELLOW LINE = STUDY AREA USED IN MANNHEIMER, 2014)

The dolomite ridges comprise the largest unmodified/natural habitat on the site and are highly diverse. It forms part of the Otavi mountain land, which is known to contain endemic and protected species. The sandy plain is more modified than the dolomite ridges due to its accessibility. A considerable degree of bush encroachment has taken place in the sandy plain areas. The alien-infested plain and drainage line habitat is located to the west of the plant facilities and originally probably also consisted of a sandy valley. Currently it has a highly modified species composition due to human influences, including high numbers of invasive alien plant species. The active plant area and tailings facilities comprise the remainder of the smelter site and these areas are highly modified with low environmental integrity.

Thirteen protected species, including 11 trees, have been recorded within the smelter boundary. Of these, the tamboti (*Spirostachys africana*) has been heavily impacted by past mining operations. In addition, six endemic species and six near-endemic species were listed. No highly threatened Red Data species were recorded, with one having a Red Data status of Vulnerable (*Cyphostemma juttae*).

As all new project components would be limited to within the existing facility footprint, no areas of remaining natural vegetation would be cleared. A study is currently underway to determine the long term

effects of the smelter operations on existing vegetation surrounding the smelter site. Recommendations from this study will be incorporated into the Closure Plan for the smelter in order to ensure appropriate rehabilitation of the site and surrounding environment. For this purpose, a nursery is currently being established for the smelter in order for appropriate plant species to be available for later phytoremediation.

4.12.2 ANIMAL LIFE

The area of Tsumeb is disturbed as a result of urban development, but it can be expected that the surrounding areas which support natural vegetation will support species of conservation concern including damara dik-dik, eland, Namibian dwarf python, leopard tortoise and possibly endemic birds such as Carp's black tit and Ruppel's parrot. Wildlife surrounding the smelter is not abundant. Kudu, steenbok, squirrels, flamingos and other birds have, however, occasionally been spotted near or on the two main slimes dams.

Natural aquatic communities are largely absent from the region as a result of the absence of surface water flow due to the high infiltration rates. Stygobiotic (living in groundwater) amphipods are characteristic of karst landscapes and are known from the areas to the north east of Tsumeb. The effects of prolonged mining operations on such species are not known.

4.13 SOCIO-ECONOMIC ENVIRONMENT

4.13.1 ECONOMIC DESCRIPTION

The DPMT smelter falls within the Tsumeb Magisterial District in the Tsumeb Constituency of the Oshikoto Region. Tsumeb is the major urban centre within the region and the economy is largely associated with the operation of the Tsumeb Mining Operations and Tsumeb Smelter Complex. DPMT currently sustains 667 direct jobs, of which 457 are employees and 210 are contractors. These jobs are associated with annual salary payments of around N\$168 million. Many other services are directly dependent on DPMT operations.

The key sectors in terms of employment in the Oshikoto region are agriculture (49%), followed by administrative and support service activities (7% of jobs), education and activities of private households (6% of jobs each). The manufacturing sector only contributes 3% to total direct employment in Oshikoto. This serves to emphasise the importance of plants such as DPMT, in providing diversification. The major contributors to the local economy of Tsumeb are given in Table 4-6.

TABLE 4-6: ECONOMIC ACTIVITIES IN THE TSUMEB DISTRICT

Economic Sectors	Major Contributors
Mining	Ongopolo Mining & Processing Limited
	Henning Crushers
	Punyu Crushers
	Weatherly International Plc.
	Tschudi Copper Mine
Agriculture	Mannheim Agricultural Area
Manufacturing /Packing	Power 4 Africa
	Tsumeb Charcoal
	Family Choice
Construction	Powerline 2000
	Brandberg Construction
	Travels 2000
Wholesale & Retail	Three shopping centres
	Electrical Equipment
	Motor Vehicle Spares and Accessories
	Fresh Produce
	Butcheries
	Brick-making and building materials
	Car Dealers
Services	Vehicle Repair
	Legal Practitioners
	Financial Institutions
	Medical Practitioners
	Three hospitals, three health care centres and 16 primary health care clinics
Tourism	Tsumeb Museum
	Minen Hotel
	Makalani Hotel
	Tsumeb Airport
	Lake Oshikoto and Guinas Lake (35-45 km north)
	Etosha Pan (100 km north)

The Tsumeb Town Council are actively promoting future development in the town which is recognised as the gateway to the north and a prime locality for attracting industrial and commercial enterprise. It is envisaged that the development of the new railway line linking Namibia, Angola and Zambia will impact directly on the economy of Tsumeb, which is best positioned to support the construction activities.

DPMT operations also provide numerous possibilities that could contribute to a significant broadening of industrial activities and value-added processing. These include:

- Refining of copper;
- Extracting base and precious metals from mine tailings;
- Reclaiming zinc and gallium from slag; and
- Producing arsenic related products such as pesticides.

The Tsumeb area with its vast source of underground waters (refer to Section 4.4) is well suited for the cultivation of fruits and vegetables and is capable of producing large quantities for marketing and canning purposes. The Mannheim area located approximately 10 km north of Tsumeb is particularly suited for this purpose. The Tsumeb Agricultural Development Project was launched in 2003 for further development of agricultural lands immediately south east of Tsumeb.

4.13.2 SOCIAL ENVIRONMENT

Tsumeb had a population of 19 840 in 2011, up from 14 907 in 2001, implying that the town had grown by 33% in this ten-year period. This was more than twice both the national (15%) and regional (13%) growth rates over the same period (NSA, 2012a; NSA 2012b). Growth since 2011 has also been robust according to municipal officials and other sources. Though not based on official statistics, the Tsumeb community needs assessment conducted for DPMT in 2015 found it likely that Tsumeb's population has grown by at least 25% since 2011 to over 25 000 inhabitants, driven primarily by the growth of informal settlements (Yarmoshuk, 2015). During March 2017 it was, however, noted by the Tsumeb Municipality that the total inhabitants might be closer to 35 000. In 2012, unemployment within the Oshikoto Region was estimated at 26.4 % and in Tsumeb at 36 %. Further details regarding the demographics of the Oshikoto Region and Tsumeb, based on the 2011 Census data, are provided in the social assessment in Appendix H2.

Tsumeb has a well-developed and maintained road network and aerodrome system. Windhoek is located 380 km away by air and 435 km by tarred road. Tsumeb is linked to the Trans Namib railway network and there is a railway siding located in the industrial section in the northern section of the town. There is an efficient sewage treatment system which currently runs below capacity, largely due to the fact that it does not receive industrial effluent.

There are 7 primary schools and two secondary schools within Tsumeb. There is also an adult education centre enabling adults to further their education. Tsumeb boasts a well organised and well equipped health service system, which includes two hospitals. There are three clinics within the town.

4.14 NEIGHBOURS AND SURROUNDING LAND USE

The Tsumeb smelter complex is located to the north of a prominent ridge which separates it from the Tsumeb Mining Area and the town of Tsumeb to the south. Two water reservoirs and a cell phone mast are located on this ridge.

The Tsumeb CBD including shops, restaurants, banks and offices, is located approximately 2.5 km south of the smelter. Ondundu Village, including a primary and nursery school is located approximately 1.2 km south east of the site. The Tsumeb Private Hospital and private boarding school, Tsumeb Gymnasium, are located in the residential area behind the ridge, approximately 1.6 km south of the smelter. The Nomtsoub residential area is located approximately 2.6 km southwest of the smelter. Other land uses located within relatively close proximity of the smelter include the western industrial area and the golf course, which are located 2 km west and 2.2 km south of the smelter, respectively. Refer to Figure 4-17 for the location of sensitive receptors in relation to the Smelter complex.

4.15 COMMUNITY HEALTH

The Community Health Assessment undertaken by Myers (2016) as part of this ESIA process investigated the current impact of the smelter operations on Tsumeb residents. This assessment thus provides an indication of the baseline community health conditions prior to the proposed Smelter Upgrading and Optimisation Project. A summary of the results of the baseline investigation are provided here. Further details are available in Appendix I.

4.15.1 COMMUNITY HEALTH HAZARDS LINKED TO THE SMELTER

Arsenic and SO₂ in air are the two principal hazards arising from fugitive emissions from the processing of complex copper concentrates at the Tsumeb Smelter that may affect the surrounding community. SO₂ gas presents risks to health, notably respiratory health disorders including asthma, respiratory infections and cardiorespiratory insult, while arsenic is a known cause of lung cancer.

4.15.2 SENSITIVE COMMUNITY RECEPTORS AND EXPOSURE PATHWAYS

Based on prevailing wind directions, air emissions from the smelter are mainly driven northwest with occasional winds from the north, potentially affecting the western industrial area and the northern part of town. Based on soil samples taken in different parts of Tsumeb and air quality monitoring along the boundaries of the smelter site, different exposure zones were determined (see Figure 4-17). The western industrial area and the northern town industrial area are nominally the most highly exposed areas in Tsumeb, but are not residential areas. Together they are considered to be part of the high exposure zone (red) which overlaps with the smelter precinct itself. The medium exposure zone (orange) comprises the Endombo residential area at the northern edge of Nomtsoub and the Ondundu residential area to the east. There are two schools located in Ondundu. The residential areas to the south of the medium exposure zone include Nomtsoub and the eastern suburbs of Tsumeb which are considered the low exposure zone (green). Kuvukiland, southwest of Tsumeb and further from the smelter is considered an even lower exposed area and is also indicated as yellow in Figure 4-16. The Namfo farms northwest of the smelter are also located in the path of wind dispersion of pollutants, but further away from the smelter.

4.15.3 URINE ARSENIC LEVELS

In terms of arsenic exposure to community residents, the baseline community health investigation found elevated urine arsenic levels for some Tsumeb residents when compared to a non-exposed control sample group from Oshakati. Four possible arsenic exposure pathways were identified, namely: drinking water, air, food and a combination of soil and dust, together with hand to mouth behaviour.

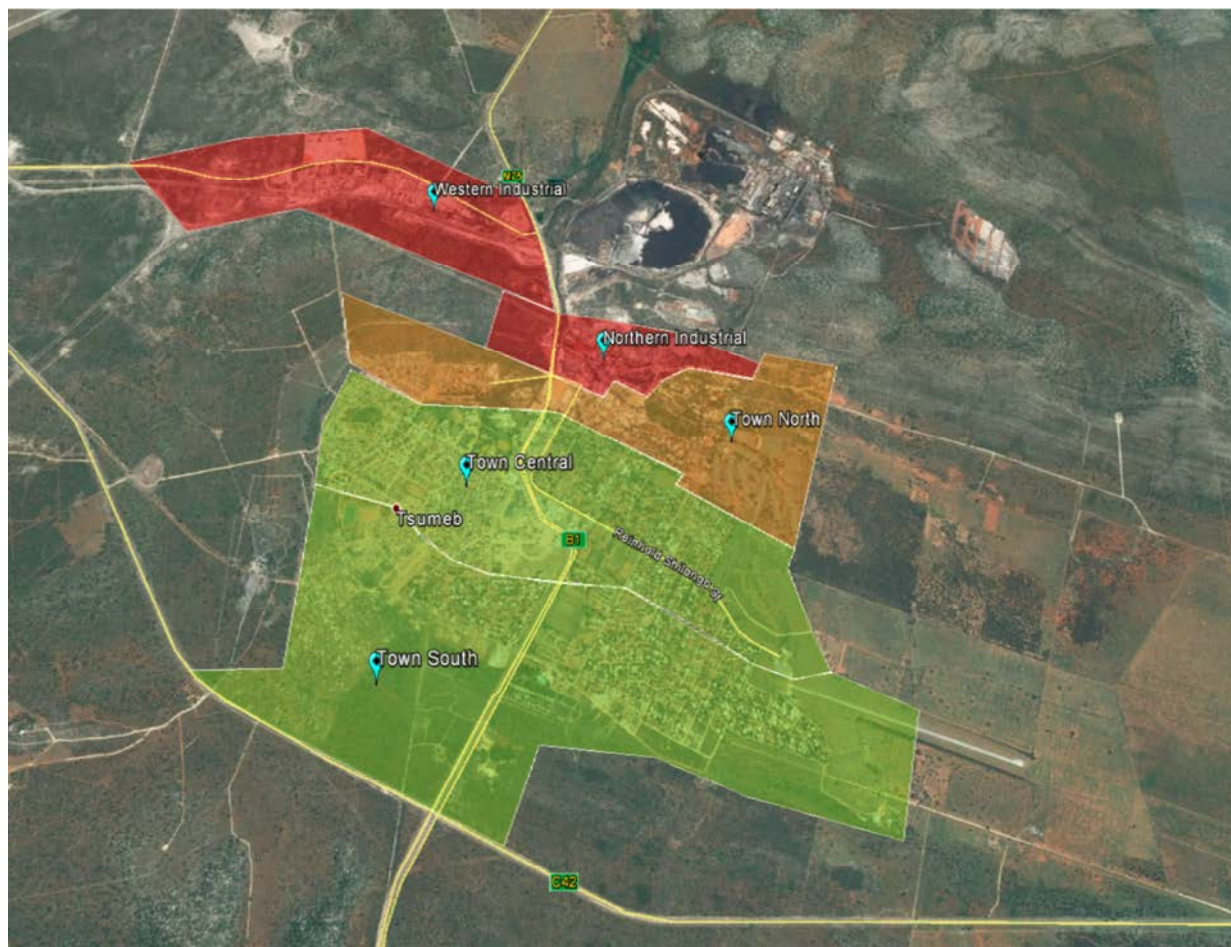


FIGURE 4-17: EXPOSURE ZONES AND RESIDENTIAL SUBURBS IN TSUMEB (MYERS, 2016)

The main findings of the investigation showed that there does not seem to be a general systemic overexposure problem based on urine inorganic arsenic for Tsumeb residents as a whole. The overall geometric mean was actually found to be well below the most conservative international occupational hygiene standard (ACGIH BEI). However, there are a small number of high exposure outliers driven by location (Ondundu in Town North) and likely behaviours (hand to mouth with ingestion of soil and dust). Town Central which has a high population density shows a short transport distance and deposition of airborne arsenic particulates over time as the arsenic in urine exposure distribution here is virtually indistinguishable from that in Oshakati which is a completely unexposed control area with regards to arsenic. Contamination therefore does not affect the entire town, but only a small area comprising Ondundu and its resident population, which need further investigation. Specifically, more sampling is required to characterise the arsenic levels in soil and locally consumed vegetables and fruit in Ondundu. More sampling is also needed for the Town South area where sample size was low.

For purposes of the investigation, normal inorganic arsenic levels in urine were defined as those falling below the highest 5% (95th percentile) of the Oshakati population's values. The expectation is that for other areas being compared with Oshakati, a number exceeding the highest 5% of the Oshakati

population's values would constitute area overexposure to arsenic. The arsenic exposure results for the different residential areas are presented in Table 4-7.

TABLE 4-7: ARSENIC EXPOSURES AS GEOMETRIC MEAN AND 95TH PERCENTILE BY RESIDENTIAL AREA

	Oshakati	All Tsumeb & surrounds	Town North	Town Central	Town South	NAMFO near farms	Remote farms
n	41	171	37	86	16	27	5
Geometric mean µg/g	10.2	15.18	21.5	12.9	22.2	12.4	19.1
95th percentile	50.4	52.2	90.6	35.6	*	41	*
n > 50 µg/g	2	10	7	0	2	1	0
% > 50 µg/g	4.8	6.4	18.9	0	12.5	3.7	0
Maximum µg/g	64.9	176.9	176.9	49.1	60.4	55.4	29.6

*Too few observations

An important finding of the investigation was that prior local studies reporting arsenic in urine levels were unreliable and misleading as the samples were not adjusted for non-toxic organic arsenic of dietary origin in the urine (e.g. organic arsenic from eating fish). Consequently, before the study by Myers in 2016, it has not been possible to estimate the absorption of toxicologically relevant arsenic from the smelter operations by Tsumeb residents. Other determinants of inorganic urinary arsenic in Tsumeb residents included direct or indirect contact with the smelter, via visits or having household members who work at the smelter. This means that some arsenic is being brought home on clothes, shoes, bags, vehicles and other objects, and probably via the hand-to-mouth route being ingested by household members. This applies to all areas of Tsumeb. For Ondundu, growing and consuming local vegetables and fruit, and picking wild fruit and edibles, also contributed to the urine arsenic burden among residents.

Based on updated drinking water samples and regular air quality and soil monitoring data, the main findings of the baseline community health investigation for arsenic exposure pathways can be summarised as follows:

Water Pathway

All measured values in drinking water samples were found to be very low in arsenic and well within the internationally accepted World Health Organisation (WHO) and European Union (EU) limit of 10 µg/l. Drinking water is thus not responsible for elevated urine arsenic levels.

Air Pathway

Based on average air quality data from the Stadium and Information Centre monitoring stations (see Figure 4-10 for locations), arsenic in PM₁₀ exposures are not responsible for raising the average urine arsenic by more than 0.33 µg/l, a vanishingly small amount. Even if arsenic in air exposures were an order of magnitude higher than this, as they are at the Sewerage Works or Plant Hill monitoring stations,

this could only raise the average urine arsenic by 3.3 µg/l – a small amount, not sufficient to explain the difference between the mean urine inorganic arsenic levels in Town North and Town Central. It is conceivable that the population of Ondundu are exposed to arsenic in air midway between 0.06 and 0.5 µg/m³, which is even less able to explain the elevation in urine arsenic in residents there.

Soil Pathway

It is highly likely that the soil is a source of arsenic exposure, both from legacy emissions and from current emissions, especially for Ondundu which is located close to the smelter site. More data need to be collected from the soil in Ondundu, together with further urine samples from households there as well as household dust. A 2016 study by Kribek *et al.* investigated arsenic concentration in the soils and grass surrounding the smelter complex and found high correlations between arsenic levels in topsoil and the rhizosphere and the arsenic content of grass in the same areas. They found that only the northern part of Tsumeb town was affected, principally the area around Ondundu. Their conclusions were, however, based on very few measurements.

An earlier study (Mileusnic *et al.*, 2014) on the health risks from arsenic exposure to Endombo residents in the extreme northern tip of Nomtsoub found that the estimated daily intake of arsenic from soil was low and did not exceed the allowable daily intake for children weighing over 5 kg. The 2016 community health investigation finding that the mean urinary arsenic level in Endombo (20.6 µg/g) was considerably lower than in Ondundu (53.1 µg/g) confirms overexposure in the latter area.

Food Pathway

There are few local data available which can be correlated with urine arsenic levels for vegetables and fruit grown at residents' homes, or for wild fruit and vegetables picked near the smelter. Such data would be of particular importance in Ondundu. Myers (2016) found that those who grow their own vegetables at home in Ondundu showed significantly higher urinary arsenic levels (55.7 vs 17.3 µg/g). Picking wild food is also highly significant in Town North, but sample numbers are small in these areas, and further sampling of arsenic in wild and grown produce and urine is needed.

Conclusion

In conclusion, mean inorganic arsenic levels for Tsumeb as a whole and its suburbs were all below the most conservative limit (ACGIH) for inorganic arsenic, i.e. below 35 µg/l or 35 µg/g (the two units are similar in number at this level). For inorganic arsenic, the 95th percentile for Tsumeb as a whole is close to the 95th percentile for the unexposed Oshakati controls and is also below the Namibian Biological Exposure Index (BEI) of 50 µg/g. With mean exposures at this level, there is no additional risk of lung cancer. The risk of lung cancer due to environmental arsenic exposure is thus low for Tsumeb as a whole. There is no risk above baseline occurrence of cancer for Tsumeb suburbs, with the exception of Ondundu in Town North where the risk remains low, mainly due to the small population size there.

4.15.4 PM₁₀ EXPOSURE

Using 2016 data from the Info Centre monitoring station, mean daily PM₁₀ exceedances per month were found to be negligible when using the Namibian (South African) limit, but 4.8 according to the WHO PM₁₀ limit.

A WHO report on the global burden of disease from air pollution in 2016 showed that more than 90% of the global population is exposed to air pollution at levels exceeding the WHO PM₁₀ limit of 50 µg/m³ daily and 20 µg/m³ annually. The article estimates the health impact of these PM₁₀ exceedances for different countries using burden of disease units of disability adjusted life years (DALYs), which integrate a measure of premature mortality measured as years of life lost prematurely (YLL), and increased morbidity in life as years lived with disability (YLD). Given the paucity of morbidity studies in low income countries the health impact is expressed in YLL only. This corresponds to a burden of disease due to air pollution as measured by PM₁₀ exceedance measured in YLL per 100 000 population as shown for different countries in Table 4-8. Namibia has a lower burden of disease than Canada (DPM Head Office location) and a substantially lower burden than South Africa (a more industrialised middle income country) and Bulgaria (an EU country where concentrate for the DPMT smelter is sourced) by comparison. Assuming a population in Tsumeb and surrounds of 35 000, the number of YLL is calculated for Tsumeb as a whole as 245. This amounts to 0.007 year per person or about 2.5 days lost on average.

TABLE 4-8: BURDEN OF DISEASE DUE TO AIR POLLUTION (WHO, 2016)

Country	YLL per 100 000 population	Number of YLL for a population of 35 000
Namibia	700	245
Botswana	657	230
Angola	1794	629
South Africa	1116	391
Bulgaria	1302	456
Canada	868	304
USA	168	59
UK	277	97
Sweden	3	<1
Netherlands	279	98

4.15.5 SO₂ EXPOSURE

Using 2016 data from the Stadium and Info Centre monitoring stations, mean daily exceedances per month for SO₂ were again found to be negligible for the South African limit, but 4.4 per month according to the WHO SO₂ limit. These SO₂ exceedances of the more stringent WHO daily limit at around once a week on average are confirmed by the results of the respiratory questionnaire administered in September

2016 in residential areas of Tsumeb (reported as perception of a bad odour at least once a week). The monitoring data showed a marked decrease from 2015 levels. An average of 12.1 daily exceedances per month of the WHO limit was recorded in 2015. The laxer South African limits were exceeded 4 times for SO₂ per month in 2015.

SO₂ exceedances have an irritant effect on the respiratory system, causing a symptom burden for the receptor population, especially for those with asthma-related symptoms.

When investigating asthma-related symptoms in relation to SO₂ during the community health study, it was found that, compared with the control sample in Oshakati, there was evidence of asthma-related symptoms being significantly more prevalent in Tsumeb. This is consistent with the 2012 Namibian Government Survey which found an excess of respiratory symptoms in Tsumeb in comparison with the control sample in Grootfontein. Half of all those in Tsumeb had some asthma-related symptomatology and half of these again experienced some degree of severity of these symptoms constituting an appreciable burden of asthma-related morbidity spread across all the areas of Tsumeb and the farms to the North. There was no visible trend in these symptoms across areas within Tsumeb which, would make sense for asthma-related symptoms which are not dose-related but can be triggered by low levels of exposure.

It should be noted that the study only encountered seven reports of an actual asthma diagnosis, with two from Oshakati and five from the Town Central area in Tsumeb. This actually amounts to a marginally higher prevalence in Oshakati (5%) than in Tsumeb (2.9%). Of these, almost all of them (6) take medication for asthma. It can be inferred that there definitely is some asthma-related impact from exposure to SO₂ from the smelter, but that this is mostly mild to moderate in severity.

Responses to the respiratory questionnaire also confirmed many statements about improvements with regards to SO₂ exposures in the residential areas made by community members at the various public participation meetings prior to the health survey. The overwhelming majority (82%) of participants indicated that the incidents of discernible SO₂ exposure were less frequent during 2016 than 2015, while only 16% felt they were more frequent.

Based on responses from the respiratory questionnaire, it is evident that there is an appreciable burden of physical effects of the SO₂ exceedances on the exposed population. The comparison with the vanishing level of these effects in the unexposed Oshakati control sample is markedly visible. The predominant symptoms reported are cough and throat irritation, which are upper respiratory system responses and compatible with respiratory irritation by SO₂. It is notable that the more severe lower respiratory symptoms such as shortness of breath and chest discomfort are considerably less prevalent. This is consistent with the mild to moderate impact on asthma-related symptoms mentioned above. Other upper respiratory symptoms are nasal discomfort and sneezing. Itchy throat discomfort was very

common, particularly in Endombo at the northern end of Nomtsoub and in the northern part of town in the commercial district. All these findings are compatible with the measured SO₂ levels from the air monitoring stations at Stadium and Information Centre. While not severe, these symptoms do, however, impose some burden of discomfort on the residents in all areas of Tsumeb.

5 DESCRIPTION OF THE PROPOSED PROJECT

This section describes the current facilities and operations at the DPMT smelter and proposed new components as part of the upgrade and optimisation project.

5.1 BACKGROUND

Various metals have been mined at the DPMT site for over a hundred years. Between 1961 and 1963 the original smelter was replaced with a new copper and lead smelter while an arsenic plant and a cadmium plant were also established for the processing of by-products originating from the smelting process. At the time, the combination of the copper and lead smelter with an arsenic and cadmium plant allowed for the interchange of intermediate products between the smelter lines and provided a suitable bleed for the arsenic and cadmium.

In mid-1998 Goldfields Namibia, the holding company of Tsumeb Corporation Limited (TCL) went into liquidation and the Tsumeb Smelter was shutdown. In 2000, the former TCL assets were taken over by Ongopolo Mining and Processing Limited (OMPL) and the copper and arsenic plants were re-commissioned. The cadmium plant was decommissioned and no lead processing has taken place since re-commissioning. In July 2006 the assets of OMPL were sold to Weatherly Mining International who owned and operated the plant for four years before selling it to Dundee Precious Metals Inc. (DPM) in March 2010. The company now operates as Dundee Precious Metals Tsumeb Ltd, a wholly owned subsidiary of DPM that is listed on Canada's Toronto Stock Exchange.

The smelter was constructed in the early 1960s to process concentrate from the Tsumeb copper mine and is one of only five commercial-scale smelters in Africa capable of processing concentrates with a high arsenic content. Currently, it receives copper concentrate from El Brocal, Peru, Chelopech, Bulgaria and Opuwo, Namibia for processing in the smelter.

Following the purchase of the smelter complex in 2010, DPMT have undertaken a series of upgrades and improvement projects, including the following:

- Construction of a hazardous waste disposal site (2012);
- Addition of a second oxygen plant (2012);
- Improvement of the off-gas handling systems (2012-2013);
- Closure of the reverberatory furnace (2013);
- Addition of a 1,540 t/d sulphuric acid plant (mid 2015);
- Addition of two new and larger Peirce-Smith converters (end 2015);
- A new effluent treatment plant; and
- Decommissioning of the arsenic plant (first quarter of 2017).

The Tsumeb Smelter now comprises of one primary smelting furnace, the refurbished Ausmelt furnace. Blister copper is produced from the copper concentrate and delivered to refineries for final processing. Up till recently, arsenic trioxide (As_2O_3) was also produced from the copper concentrate through the arsenic plant and sold to third parties. With the recent decommissioning of the arsenic plant, As_2O_3 production has ceased.

The general layout of the smelter site and its main operating infrastructure is provided in Figure 5-1. A larger layout plan indicating the location of tailings facilities and stockpile areas is provided in Figure 5-2.

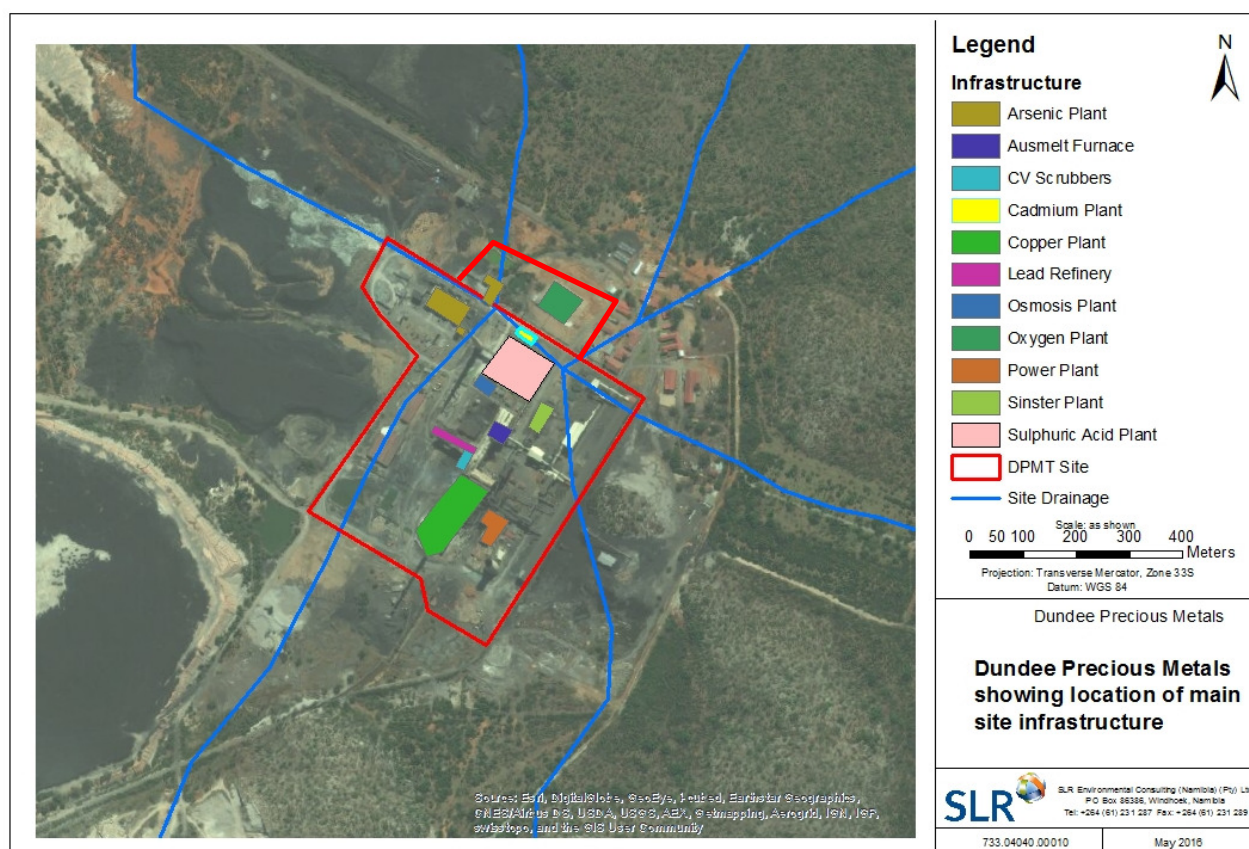


FIGURE 5-1: GENERAL LAYOUT OF THE DPMT SITE AND INFRASTRUCTURE

5.2 DESCRIPTION OF CURRENT OPERATIONS

This section provides a description of the existing approved operations at the DPMT smelter. A simplified process flow diagram of the current operations is provided in Figure 5-3 and a more detailed flow diagram is provided in Figure 5-4.



FIGURE 5-2: LAYOUT OF GREATER SMELTER AREA, INDICATING TAILINGS STORAGE FACILITIES AND OTHER STOCKPILES AND SUPPORTING INFRASTRUCTURE

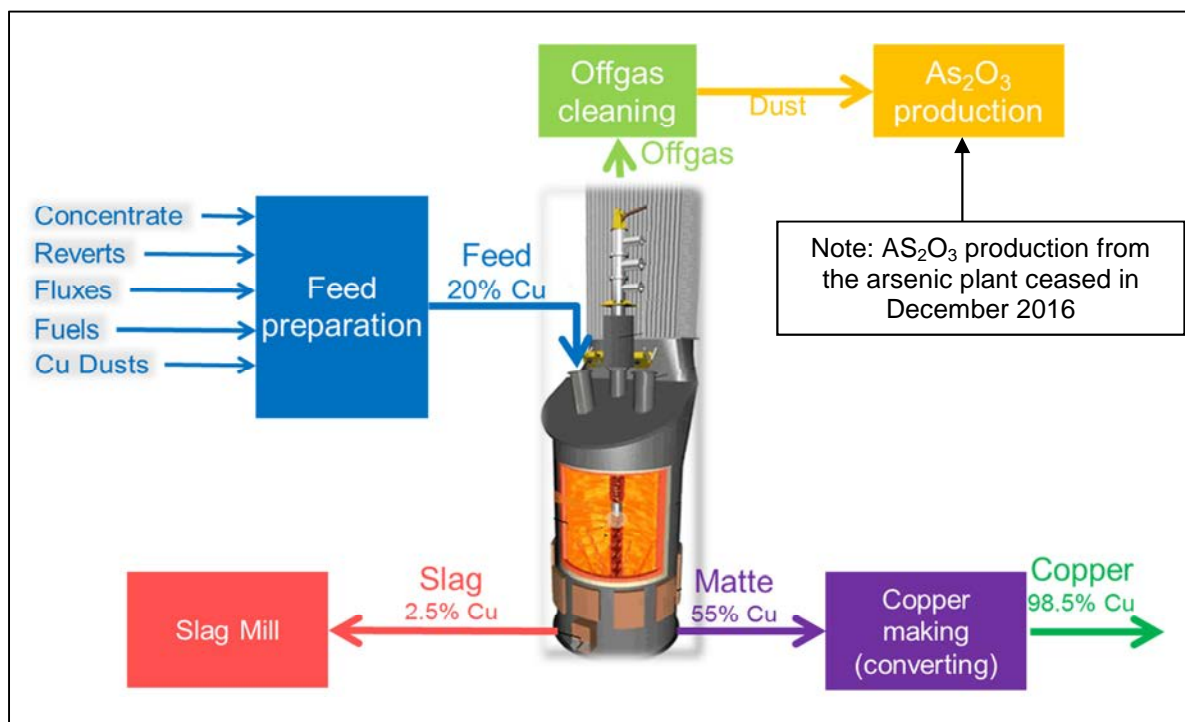


FIGURE 5-3: SIMPLIFIED FLOW DIAGRAM OF THE CURRENT SMELTER OPERATIONS

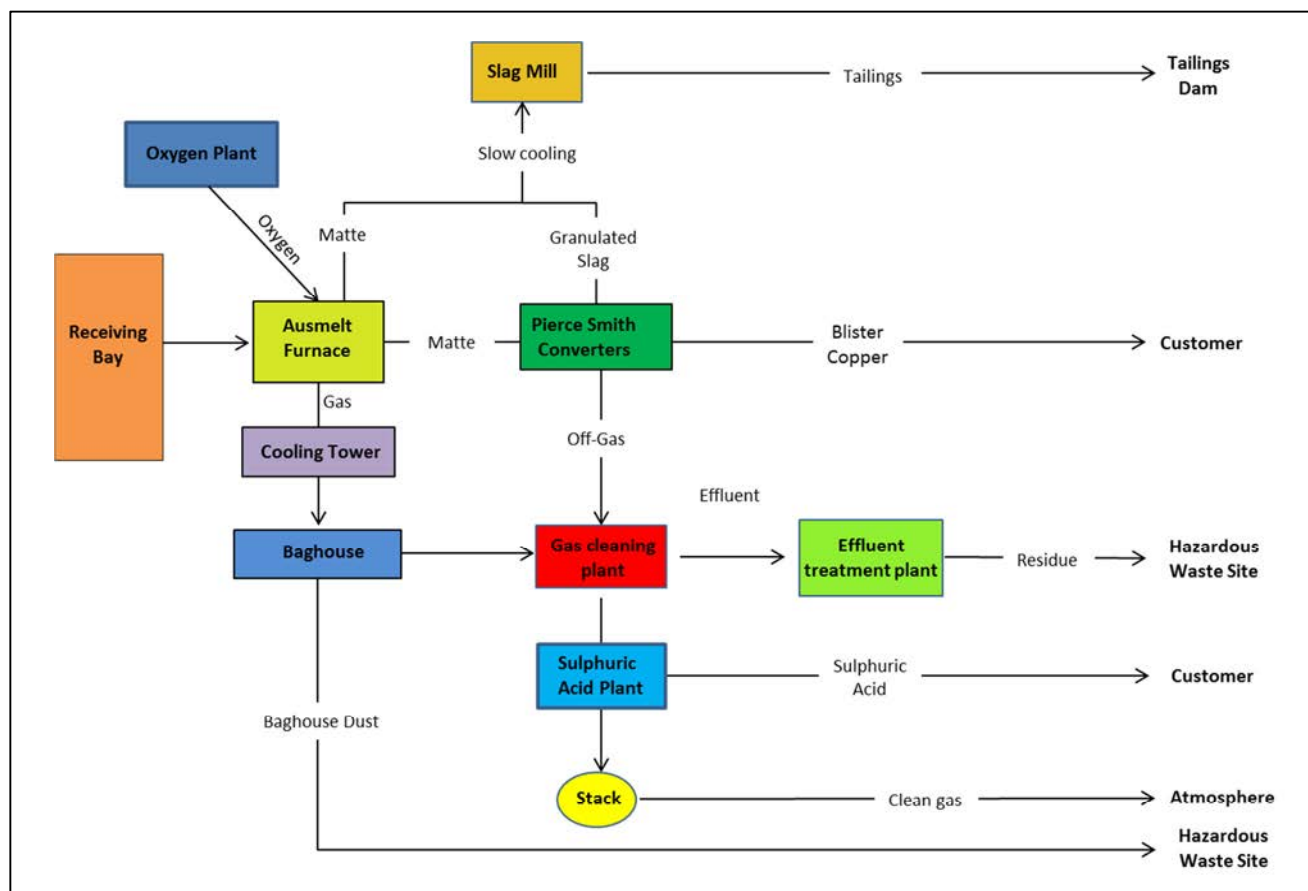


FIGURE 5-4: FLOW DIAGRAM OF THE CURRENT SMELTER OPERATIONS AS AT MARCH 2017

5.2.1 RECEIVING BAY

The majority of materials and concentrates are received by rail and are off loaded at the receiving bay. Materials received include coal, silica and, concentrates. These are stockpiled in different sections for use.

During the preparation of charge for the Ausmelt furnace the necessary fuel, concentrates and additional materials are (crushed and) blended for introduction into the furnaces. The charge for the Ausmelt is pelletised in a small pelletising plant.

5.2.2 AUSMELT FURNACE

The Ausmelt furnace has been refurbished to smelt copper concentrates and was re-commissioned in 2008. The Ausmelt is a Top Submerged Lance (TSL) furnace that is charged with pelletised copper concentrates and fuelled with heavy furnace oil and coal. The melt consist of two phases, namely matte (molten metal sulphide phase formed during the smelting of copper concentrate) and slag (silicate waste product from smelting) which are tapped separately at different elevations. During the smelting process however, the molten material which has a relatively low volume, experiences intensive stirring which does not allow for good separation between the two phases. Matte from the TSL goes directly to the converters. The slag is transferred to the slow cooling process and is then crushed. The crushed material is transferred to the slag mill and float plant where the entrained valuable metals, consisting mainly of copper, are recovered.

Off-gases from the Ausmelt pass through evaporative coolers and are then filtered through the baghouse where the dust which contains arsenic, is captured. The filtered gas containing SO₂ is transferred to the sulphuric acid plant gas cleaning system. Fugitive gases from the tap holes and matte launder are captured and filtered through the hygiene baghouse and are released to the atmosphere via the copper stack. Alternatively, gases from the Ausmelt are bypassed to the Ausmelt stack for short periods during start-up and shutdown or during emergency plant stoppages. Arsenic-containing dust recovered at the baghouses is disposed of at the Hazardous Waste Disposal Site. Approximately 25% of this collected dust was previously processed at the arsenic plant for the production of arsenic trioxide (As₂O₃).

5.2.3 PEIRCE SMITH CONVERTER FURNACE

Molten matte material tapped off the Ausmelt furnace is transferred to the converter furnace for the final production of blister copper. Oxygen enriched air is added to the matte material and the oxygen reacts with sulphur, iron, lead and zinc. The sulphur from the metal sulphides provides the energy (exothermic reaction) to complete the conversion of matte to blister copper. The blister copper (98.5 % Cu) is cast into 1.62 tonne bars for shipment to refineries.

Slag formed in the converter is either recycled to the converter if it contains large amounts of entrained matte for further smelting or it is slow cooled and crushed prior to treatment at the slag mill.

The hot primary off-gases (more than 90 % of the total gas stream) from the converter pass through a wet scrubber gas cleaning system and the clean gas is then directed to the sulphuric acid plant gas cleaning system. The remaining fugitive gasses that are captured during slag and matte tapping are passed through a balloon flue before being cooled in a series of U-tubes, followed by further cooling in the new gas cooling tower. The tower was installed in February 2010 in order to provide additional cooling of the gases before they pass through the converter section of the copper baghouse prior to being released through the copper stack at the southern section of the smelter. The ducting required to carry the off-gases has subsequently been replaced. The baghouse has also been extended to increase its capacity.

5.2.4 REVERTS

Some of the molten material, that flows through launders and is transferred in ladles, freezes on the walls of these transfer vessels and form coatings referred to as skulls or shells. The skulls, along with material that is inadvertently spilled, are collected as so-called reverts and are recycled to the Ausmelt.

5.2.5 GAS CLEANING

The gas cleaning plant processes off-gases containing a variety of impurities with different concentrations from both the Ausmelt furnace and the Peirce-Smith converters.

The primary gases from the Ausmelt and the converters have different properties and impurity loads. While the gas from the Ausmelt has already been cooled down in evaporation coolers and de-dusted in a baghouse filter prior to the sulphuric acid plant, the gas from the converter contains a high dust load, depending on the blowing cycle of the converter.

The gases from the converter as well as the gas from the smelter are directly quenched and scrubbed in high efficiency scrubbers with an integrated quench section, each followed by a droplet separator and an ID Fan. The gas streams from the converter and the smelter are combined and then treated in a common gas cooling tower and four wet electrostatic precipitators (WESP's).

5.2.6 ARSENIC PLANT AND BAG HOUSE

Concentrates and other secondary material processed at the smelter are traditionally high in arsenic. The majority of the arsenic passes through the smelter and is captured from the off-gases in the bag houses. Up until December 2016, arsenic was processed in an arsenic plant, producing 99% arsenic trioxide for transport to market. With the decommissioning of the arsenic plant, bag house dusts with high arsenic levels are directly disposed of at the hazardous waste disposal site.

The bag house has been improved in recent years as per the currently approved EMP requirements. The original bag house was removed and replaced with a newer facility in order to improve efficiency.

5.2.7 SLAG MILL

Slag material skimmed from the various furnaces is slow-cooled and crushed before being passed to the slag mill for milling and concentration of copper by conventional flotation. The concentrates produced are re incorporated into the smelting process. The tailings produced during the flotation process are deposited on the old tailings dam located to the west of the smelter.

5.2.8 POWER PLANT

Electrical power for the majority of the smelter operations was historically supplied by an on-site power plant. The power plant has been decommissioned in recent years and electrical power is drawn from the national grid as required. However, the cooling component of the power plant is still in use.

5.2.9 OXYGEN PLANT

An oxygen plant was commissioned in February 2010 in order to increase production at the Ausmelt. The oxygen plant extracts oxygen from air and produces oxygen (96% O₂). The oxygen is injected into the Ausmelt furnace where it will react predominantly with iron and sulphur through exothermic reactions. As a result of the additional heat in the Ausmelt it is possible to smelt greater quantities of copper concentrate and thus increase production. Burning of the sulphur in the concentrate also reduces the consumption of fuels such as coal and heavy furnace oils. The additional heat from the sulphur and oxygen provides for a higher smelting rate.

A new oxygen plant and associated infrastructure was commissioned in January 2014.

5.2.10 SULPHURIC ACID PLANT

The plant is located in a brownfield development site within an existing footprint of the plant and was commissioned in 2015. The sulphuric acid plant has two main steps in its process, the pre-treatment of gas (gas cleaning) and gas conversion. A simple overview of these two steps is discussed in the subsequent sub-sections.

5.2.10.1 GAS PRE-TREATMENT (GAS CLEANING)

Gas cleaning takes place as described in Section 5.2.5, after which it is fed to the sulphuric acid plant.

5.2.10.2 GAS CONVERSION

The single-train Sulphuric Acid Plant is based on the double absorption process with a catalytic converter consisting of three beds. After gas pre-treatment, the sulphur dioxide in the gas is converted to sulphur trioxide in a contact process that takes place in a catalytic converter, containing a vanadium pentoxide and a caesium (final bed) catalyst. During this process a high efficiency of conversion of sulphur dioxide to sulphur trioxide takes place. The double contact double absorption technology allows absorption of sulphur trioxide into 98.5% sulphuric acid. This occurs by means of exothermal chemical reactions.

The sulphuric acid that is produced is stored in three onsite storage tanks from where it is loaded into rail (this is a primary form of transport) and road tankers and transported to local and international clients.

5.2.10.3 SULPHURIC ACID PLANT COMPONENTS

The main components of the Sulphuric Acid Plant are listed below.

Gas Pre-treatment

The gas pre-treatment section includes a:

- Scrubber;
- Gas cooler;
- Wet Electrostatic precipitator;
- Effluent stripper, including a holding tank; and
- Weak acid area, including a sump.

Contact Section

The catalytic converter section includes the:

- Drying tower, with an acid mist eliminator;
- Converter with three (3) catalyst beds;
- Stack - The diameter of the stack will be 2.7m with the top section tapered to 1.8m. The height of the stack will be approximately 60m – 80m;
- Preheater;
- An inter-pass absorbing tower and a final absorbing tower with acid mist eliminators; and
- The strong acid area, including a drying acid pump tank, absorbing acid pump tank and a drying acid cooler.

Product Storage

The product storage area which will include:

- Three product acid storage pump tanks and associated infrastructure;
- Rail car and road tanker loading facilities; and
- An acid storage area sump.

Utilities

The associated utilities will include the:

- Water treatment plant;

- Tempered water tank (tempered water is water in the temperature range between 29°C and 43°C, which is required for eye wash and safety showers); and
- Safety showers and water pumps.

5.2.11 EFFLUENT TREATMENT PLANT

The Effluent Treatment Plant is designed to treat effluents from the gas cleaning plants of the smelter and converter plant area. Effluents from the gas cleaning plants (including wash down water, accidental spills, cooling water blow down, precipitate collected in containment sumps, laboratory wastewater and stormwater) are pumped to the effluent treatment plant where they are purified in a precipitation process. Sulphuric acid, arsenic, and other soluble impurities are precipitated by adjusting the pH (i.e. adding milk of lime). The Effluent Treatment Plant process consists of areas for neutralization, clarification, filtration, and an area for reagent preparation. The purified effluent is discharged from the effluent treatment plant at the process pH of approximately 11 (required to remove arsenic below the target level) and joins the smelter return water stream. Solid wastes from the effluent treatment process are disposed of at the onsite hazardous waste site.

5.2.12 SEWAGE TREATMENT PLANT

Construction of the sewage treatment plant was completed in 2014. The plant is currently not fully operational due to oil and other waste water entering the sewage system. A project is currently underway to investigate the source of the contamination and to fully commission the sewage treatment plant.

5.2.13 KLIPLIME QUARRY

DPMT requires limestone for its operations and currently holds an ECC for mining operations at the Kliplime Quarry to the east of Tsumeb (see Figure 5-5). The ECC allows DPMT to continue quarrying for limestone from the existing Kliplime Quarry in order to meet its operational requirements. Quarrying operations include drilling, blasting and loading of limestone onto trucks for transport to the Tsumeb Smelter complex. Drilling only takes place in daylight hours on weekdays. Biannual blasting operations release approximately 8 000 to 10 000 tonnes of limestone from the quarry. Additional blasting only takes place if back-up stock is required. Once blasting is complete, a front-end loader collects all blasted rock, which is placed on a transport contractor truck for transport.

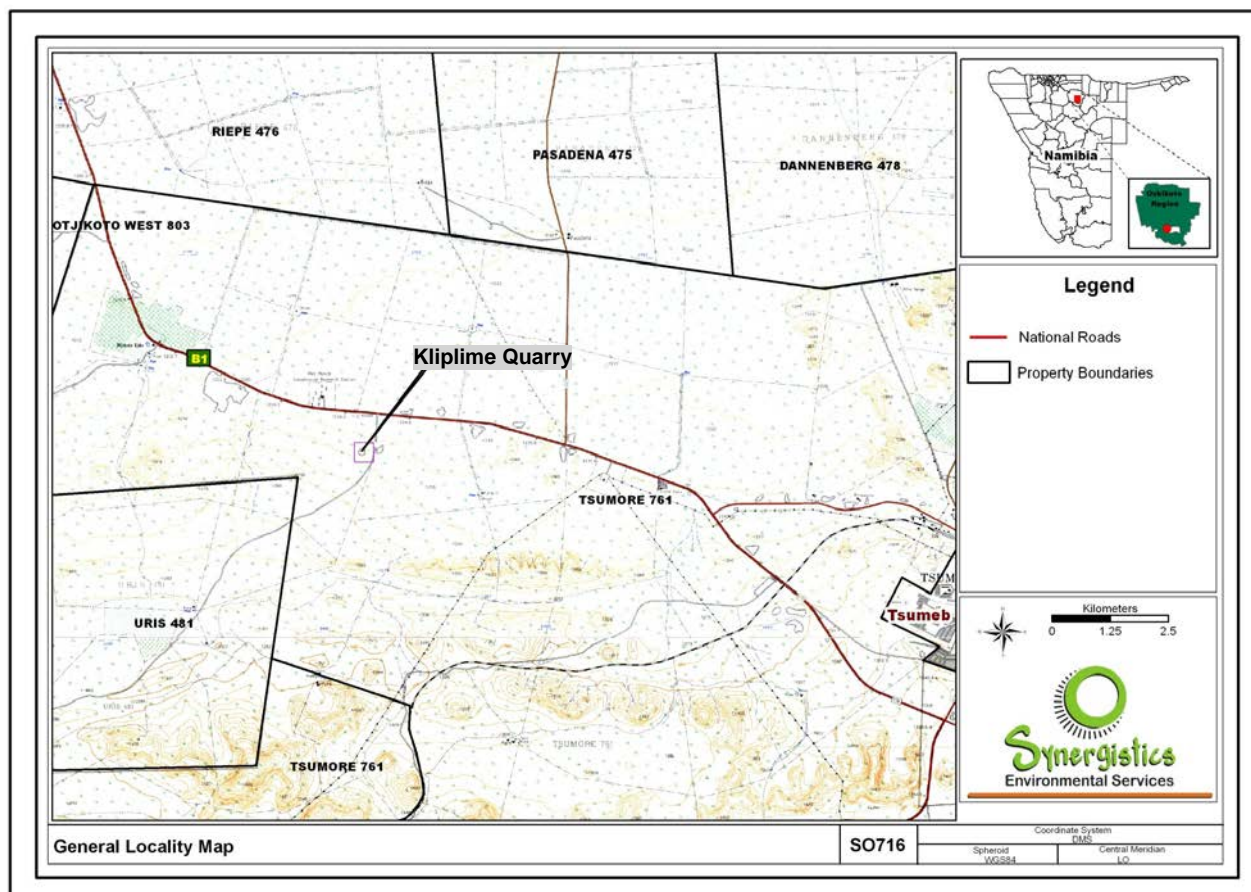


FIGURE 5-5: LOCATION OF THE KLIPLIME QUARRY TO THE EAST OF TSUMEB (SYNERGISTICS, 2013)

5.2.14 OTHER INFRASTRUCTURE AND OPERATIONAL COMPONENTS

Other infrastructure present on site includes:

- Admin and support buildings;
- Offices (container offices);
- General warehouse;
- Engineering workshops;
- Canteen;
- Reservoirs;
- Roads (gravel and tar); and
- Rail loop.

5.2.15 WASTE SITES

5.2.15.1 Blast Furnace Slag Dump

Slag originating from the blast furnace in the lead section of the smelter was historically disposed on site and resulted in the formation of an extensive blast furnace slag dump which is still present on site. The blast furnace has not been in operation since the operations ceased around 1994 and thus blast furnace

slag is no longer produced.

5.2.15.2 Tar Pits

The tar present on the site originated as a waste product produced from a “gas producer” that was in operation in the past. The gas producer was utilised to generate gas used to fire the lead furnaces the sinter plant as well as the arsenic roasters at the arsenic plant. A combination of coal and wooden blocks were used as a fuel for the gas produced. The wooden blocks were supplied by local farmers in the area. The process resulted in the production of tar and ash and this material was frequently cleaned from the cyclones and gas pipes at the gas producer plant. The plant has not been operated for many years.

The tar was disposed of in drums or directly onto surface at various sites at the smelter. Four existing tar disposal sites are currently known. Cleaning up of these tar pits is currently managed by the approved EMP.

5.2.15.3 Old Slag Mill Tailings Dump

Historically the tailings originating from the slag mill were deposited north of the slag mill adjacent to the access road to the smelter. The dump contains high levels of metals including copper. The newer tailings dam to the east of the smelter was used for the disposal of slag mill tailings under the previous Smelter owner's operations. DPMT currently disposes of the slag mill tailings in the reworked section of the old tailings dam located west of the smelter.

5.2.15.4 Mine Tailings Dumps

Tailings originating from the Tsumeb Concentrator were deposited on a tailings dam located within the Tsumeb Smelter Complex, referred to as the “old tailings dam”. TCL decided to rework a section of this tailings dam, necessitating the need for a new tailings dam which was established as a valley fill to the east of the smelter complex.

The new tailings dam was used by OMPL both for slag mill and mine tailings originating from the Tsumeb Concentrator (when it was in operation). The eastern tailings dam is no longer in use and requires rehabilitation. DPMT have made use of the reworked section of the old tailings dam for the disposal of slag mill tailings.

Linked to the old tailings dam is a return water dam, evaporation ponds and associated pump houses. Also linked is an old building and transformer (seeping) at the floor of the old tailings dam. Only the return water dam is, however, currently being used by DPMT.

5.2.15.5 Arsenic Calcines Dumps

Calcines are produced in the arsenic roasters as a waste product. When the lead smelter was in operation the calcines were used as a feed into the blast furnace. However, from 1988 the quantity of calcines produced was in excess of what could be used as a feed into the lead smelter. The excess material was dumped on a section of the blast furnace slag dump, west of the arsenic plant. Some

calcines were also produced by OMPL and dumped adjacent to the TCL material. It must be noted that this is deemed to be historical waste not produced by DPMT.

5.2.15.6 Hazardous Waste Disposal Site (HWDS)

The HWDS is located within an old rock quarry located south of the Smelter Complex on a ridge separating the Smelter from the town of Tsumeb. The site is within the DPMT property boundaries, approximately 650 m north east of the old Tsumeb Mine (19° 14' 10"S & 17° 43' 20"E). The quarry (and hence the approved landfill footprint) covers an area of approximately 5 ha.

Quarrying activities at the proposed site have resulted in the formation of two terraces, with the northern section having been excavated to a depth of approximately 8 m lower than the southern section. The waste site has been developed in the lower section along the northern section of the site.

The HWDS was constructed in 2012 and has been designed with both a synthetic (HDPE) and clay liner, an under drainage system for the collection of leachate originating within the waste and a leachate detection system which provides for the monitoring of the competency of the liners. The facility has approved capacity to contain approximately 201 500 m³ of hazardous waste. Some optimisation of the site within the approved/permitted boundaries was undertaken in 2014/2105. As per the existing approved EIA, a further small construction within the existing (old) quarry footprint is allowed and is currently proposed for development in the near future.

The current estimated lifespan of the site and expected impact of the increased throughput capacity of the smelter is further discussed in Section 5.4.8.

5.2.15.7 General Waste Disposal Site

General waste including domestic waste and office waste is disposed of within the smelter property. Workshop waste is disposed together with this waste at a site located to the east of the old tailings dam and immediately south of the smelter buildings.

Recyclable general waste (cans, papers, plastics, glass) is collected at three recycling stations on site and removed by an independent waste contractor for recycling and processing off-site.

The option of adding an incinerator for the handling of general waste is currently being considered in place of a formal general landfill site within the Smelter Complex. A cost-benefit analysis was undertaken to investigate the two options (see Section 9 in Appendix D). DPMT currently holds an ECC for a general landfill site. If an incinerator is to be used, a separate EIA application process will be followed.

A review of DPMT's current waste management practices was undertaken by SLR (see Section 5.3 and Appendix D). A number of shortcomings were identified and recommendations made for improvement. These measures have been included in the Consolidated EMP (see Appendix K).

5.2.15.8 RCC Quarry Operations

The Namibian Roads Contractor Company (RCC) operates a quarry in the property of the smelter. The quarry was established to produce construction material used for the Northern Extension Railway development from Tsumeb to Ondangwa.

The quarry does not operate on a full time basis and when it does it is responsible for its own dust suppression and general environmental management. DPMT provides general oversight of the operations of the quarry insofar as they have the potential to contribute to DPMT's overall environmental impact.

5.2.16 TRANSPORT REQUIREMENTS

In terms of transport requirements to Tsumeb, DPMT depend on both road and rail services for its incoming and outgoing concentrate and product streams. DPMT's current transport needs are provided in Table 5-1. DPMT relies on companies such as Grindrod for handling and storage of concentrate at the Walvis Bay port bulk terminal. The company employs 26 staff and it was determined that Grindrod currently relies on DPMT for a substantial portion of its turnover (Van Zyl, 2016).

Copper concentrate is currently offloaded at the Grindrod bulk handling facility in the Port of Walvis Bay. The facility handles concentrate for DPMT and coal. In terms of the current operations, ~ 30-40 000 tonnes of copper concentrate is stored at the bulk handling facility at any given time and 40 000 tons of coal. An average of one ore carrier (~ 30 000 tons) per month docks and is offloaded. The concentrate for DPMT currently comes from Chile and Bulgaria, with the material from Chile making up the bulk. With the decommissioning of the arsenic plant, arsenic trioxide exports will cease.

TABLE 5-1: DPMT'S CURRENT TRANSPORT REQUIREMENTS (VAN ZYL, 2016)

Direction and nature of load	Approximate volume per month	Current	
		Truck trips per month	Train wagons per month (wagon capacity 42 Mt)
Inbound			
Concentrate and other imports through Walvis Bay	20 000 - 24 000 Mt	404	238
Coal imports through Walvis Bay	800 t	0	20
Total		404	258
Outbound			
Blister exports through Walvis Bay	3 000 - 4 000 Mt	115	0
Sulphuric acid to Rossing Mine	18 000 Mt	0	400
Sulphuric acid to Tschudi Mine	2 500 Mt	60	0
Arsenic exports through Walvis Bay	300 - 400 t	0	8
Arsenic exports to South Africa	80 - 100 t	3	0
Total		178	408

5.3 WASTE MANAGEMENT REVIEW

As part of the current ESIA process, a review was undertaken by SLR of DPMT's current waste management strategies and operational procedures for both general and hazardous waste. This was undertaken in order to identify any shortcomings prior to the proposed expansion of operations at the Tsumeb smelter and to recommend additional waste management measures for inclusion in the Consolidated EMP (see Appendix K). A summary of the findings is provided below.

5.3.1 CURRENT WASTE MANAGEMENT PRACTICES

Key waste management facilities were visited and discussions held with DPMT's Environmental Department. The following key comments were made and shortcomings identified:

Hazardous waste disposal site

SLR's review of the operations manual, and site visit, illustrated that the hazardous waste disposal site is being managed and operated in accordance with operational specifications. This is further supported by the fact that there appeared to be no definitive contamination of groundwater in the vicinity of the waste site. It is however recommended that additional dedicated monitoring boreholes be installed to confirm this and for long term monitoring.

SLR consider that the HWDS operational manual and procedures are adequate, but suggest that the addition of an effective dust suppressant chemical to the water used for dust suppression, which is harmless to the environment, as well as temporarily covering unused areas with a tarpaulin, would further increase the efficacy of the dust control on site and prevent offsite arsenic contamination.

Scrap yard:

There was no indication in the Scrap Management Procedure for the differentiation or separation of scrap from waste. Neither was there indication of how the scrap yard manager returns post-scrap wastes into the waste management system. It is recommended that a procedure be put in place to ensure that any scrap is appropriately decontaminated before going to the scrap yard.

Building rubble stockpiles:

A variety of building rubble and demolition waste heaps were observed. Such wastes should be inert, but some mixing of rubble with hazardous (e.g. refractory bricks, gas canisters, hydrocarbon drums and paint tins) and general waste items were observed. It is suggested that a process be put in place to review the content of the existing building rubble heaps to identify hazardous waste components. Those that continue to result in risk to the environment should be removed. It is recommended that a procedure be put in place to regulate the establishment of any further building rubble and demolition waste stockpiles.

Contractor workshops and yards:

There was evidence of inadequate waste management practices at some contractor yards. It is recommended that contractors be advised on the Waste Management Procedure and contractually obliged to comply with the requirements thereof.

Bins and skips around facilities:

A consistent approach to the use of coloured and labelled containers in line with the Waste Management Procedure should be implemented. Bins and skips for hazardous waste must be located in bunded areas, and preferably under roof or such containers should have lids.

General waste handling area:

The current general waste handling area was identified as a cause of concern and its operation is likely to be resulting in impacts to the environment as well as occupational health risks. General waste handling is not currently taking place in a formalised central location and some hazardous waste items were identified within the handling area (e.g. Tyvek suits). This approach is not considered to be in line with responsible best practice waste management, as general and hazardous wastes should be managed separately from source.

The second concern is that the general waste handling area is operating as a waste burning and disposal area without appropriate facilities and subject to limited management. Site operations are not currently in line with best practice for waste management. The following recommendations were made for the waste handling area:

- Management and operations of this general waste handling area need to be revised as soon as possible and a waste disposal solution added.
- No hazardous wastes should be delivered to the general waste handling area, or the general waste site handling area could be upgraded to include a dedicated area and facilities (bunded and under roof) for the storage and handling of hazardous wastes.
- The source practices which are resulting in hazardous wastes being included in the general waste stream are to be altered immediately.
- Recyclable materials should be collected and stored at one location for further sorting and or processing (only be relevant if a market can be established for recycling of such materials).
- The residual portion of the waste stream requiring disposal should be subject to improved management. Open air burning of such wastes is not an acceptable waste management solution and should be stopped immediately. An alternative, improved solution must be implemented for the disposal of residual waste.
- If such burning were to continue in the short-term (for practical reasons) then the disposal of the resultant ash onto the ground at the general waste handling area must be stopped immediately. It is recommended that the ash should be disposed to the Hazardous Waste Site.

The general waste disposal site used by the Tsumeb Municipality is neither a designed nor approved landfill site, but rather a dumpsite (pers comm, Tsumeb Municipal official). As an international company, it would not be appropriate for DPMT to dispose of waste at that facility. The alternative for DPMT to undertake responsible disposal of general waste would be the establishment of a general waste disposal site at the Tsumeb Smelter or the installation of a small incinerator to manage the residual, general waste stream. A third alternative would be to liaise with the Tsumeb Municipality and work together to ensure that a licensed, properly designed facility is constructed for the town. DPMT could then make use of the municipal landfill for general waste disposal. This alternative would also resolve the municipal waste issues.

Since the waste management review, DPMT has continued to formalise waste collection points by providing skips for the sorting and collection of different waste items. This is regarded as a positive development in terms of improving general waste management on site.

Sewage plant:

The sewage plant is relatively new and therefore anticipated to be adequate to manage the sewage requirements of the DPMT. An investigation is currently underway to identify the source of hydrocarbons entering the sewage plant. Only after this investigation has been completed and remedial measures implemented would it be possible to fully commission the sewage plant. Appropriate health and safety signage as well as environmental monitoring is recommended for the lagoon/reed bed near the calcine dump where untreated effluent is being pumped. The use of the reed beds for sewage treatment is being undertaken in terms of an exemption permit issued by the Ministry of Agriculture, Water and Forestry. The permit, however, expired in 2016. Due to the unexpected temporary shutdown of the sewage plant system, the permit renewal for temporary discharge to the reed beds is still to happen.

Projects yard:

A number of wastes or redundant/damaged materials and containers were noted. It is recommended that measures be put in place to ensure that:

- All wastes are removed from these yards to appropriate storage or disposal sites;
- Contractors or project teams are made responsible to remove and manage appropriately all wastes during, and at the end of, a project or contract.
- A project yard does not become a storage site for wastes, or materials that become wastes due to the exposure received.

Storm Water Management:

It was noted that few, if any, of the waste management facilities are equipped with storm water management systems. Exposed wastes are likely to be contributing to a reduction in the quality of storm water. In addition the sediments derived from the waste management facilities are likely to be contributing to blockages of the drainage systems. DPMT have conducted an assessment for the remediation of the storm water management systems which includes the containment of contaminated surface water runoff in new lined pollution control dams, the construction of concrete lined stormwater channels to replace the existing damaged system and the separation of clean and dirty runoff water with an earth embankment. The required upgrades to the stormwater management systems are currently being undertaken by DPMT in phases.

General Waste Landfill Site:

DPMT obtained environmental clearance from the MET (dated 9 August 2013) for the establishment of a General Waste Landfill Site at the Tsumeb Smelter. The general waste landfill site has not yet been constructed, but the approved design will form part of the current consolidated ECC being applied for and related management measures for the future waste site are included in the Consolidated EMP in Appendix K.

In the absence of the formalised general waste landfill site, general waste management operations at the Tsumeb Smelter are likely to be resulting in human health risk as well as contributing to environmental pollution. In the cumulative context of the Tsumeb Smelter it is likely that many of these impacts would, however, not be significant, or detectable. Without the general waste landfill site, impacts that should have been managed will have occurred and will continue to occur until such time as the site is constructed, or measures are implemented to enable sanitary general waste management at the Tsumeb Smelter.

As part of the waste management review it was recommended that the development of the general waste landfill site be undertaken as soon as possible in line with the approved design. As stated in Section 5.2.15.7, an alternative option for DPMT may be the development of a general waste incinerator to enable the disposal of non-recyclable components of general waste arising at the Tsumeb Smelter. This option is currently being considered by DPMT from a cost-benefit perspective, also taking technical and environmental aspects into consideration.

Laboratory Waste Management Practices

Chemical wastes from the laboratory are neutralised where necessary and then pumped to the effluent treatment plant. This practice is considered appropriate, provided that none of the chemical wastes compromise the treatment efficacy at the effluent treatment plant. Records should be kept of all chemical wastes disposed from the laboratory.

Recycling Practices

Very limited recycling is undertaken at the smelter. Other than the active recycling of scrap metal, SLR did not observe any meaningful recycling practices. Despite the presence of recycling stations at some of the facilities, it was evident from observations that paper, cardboard, plastic, polystyrene, wood, cans and glass are currently burnt rather than being recycled. This is not in line with best practice. It is, however, acknowledged that it would not be responsible to recycle wastes from areas where it could've been contaminated with arsenic dust.

It is understood that recycling practices in the Tsumeb region are not economically viable due to the long transport distances. Thus while DPMT generates wastes that are recyclable (and in reasonable volumes) prevailing market economics may prevent recycling from being viable. It is possible that new recycling industries are established in the future and therefore, the DPMT should continue to investigate any opportunities. It is suggested that the DPMT consider implementing a Corporate Social Initiative project in order to enable the establishment of initiatives for recycling of key recyclables generated at DPMT (perhaps to subsidise the transport of recyclables). Such a project could incorporate wastes from DPMT and Tsumeb town in general.

Tailings Facility

Concerns were identified regarding the current condition and management of the tailings storage facility. These included major erosion that has taken place on the side walls of the tailings dam and the fact that contamination of soil and groundwater is highly likely taking place beneath the tailings dam due to the facility not being lined.

DPMT are already exploring options for the requisite rehabilitation of the tailings facility to deal with these issues, based primarily on phytoremediation, which would appear a reasonable approach – this should be quantitatively illustrated to be comparable to best practice options such as the installation of a non-infiltrating capping layer going forward. SLR concluded that for the active portion of the tailings dam, it would be advisable to continue operations and any future expansion in accordance with South Africa's Department of Environmental Affairs (DEA) GN R.632 Regulations Regarding the Planning and Management of Residue Stockpiles and Residue Deposits. These regulations provide details on the design of stockpiles in relation to height, slope angles, handling of stormwater, etc. This will not only bring DPMT in line with local and international best practice but will also help to ensure the long term stability and safety of the tailings dam.

Conclusion

It is evident from the above summary that there is definite room for improvement with regards to current waste management practices. The formalising of a general waste disposal site (either on site or in collaboration with the Tsumeb Municipality), or alternatively the establishment of an incinerator, as well

as implementation of recommended waste management measures as set out in the Consolidated EMP, would ensure an improvement in waste management on the site in line with international best practice.

5.3.2 LEGACY WASTES

Historic or legacy wastes from smelter and mining operations by previous owners of the facility are stockpiled around the DPMT site. These comprise mostly of slags (from the furnaces and converters) and arsenic calcines and dusts. This waste has been generated over decades of operation at the Smelter and is widely distributed across the site. None of the legacy wastes (other than approximately 390 tons of arsenic calcine) are located in facilities that are designed or managed in terms of current best practice. The nature of these materials is such that they may be hazardous and may have resulted in ongoing environmental pollution and degradation. The owners of the smelter prior to DPMT's purchase of the facility established a Trust to deal with historical environmental liability and remediation. Liability for historical contamination is the responsibility of the Trust and not DPMT, as responsibility did not vest to DPMT upon purchase. The present status of the Trust is unknown and would need to be confirmed by MET. DPMT's asset retirement obligations (ARO) has a closure plan in place for the smelter, together with a set financial provision which has been independently calculated. DPMT is obligated to report their ARO provision on its books. The closure plan is required by government and commits to, at the end of the life of the facility ("scheduled closure"), rehabilitate all contaminated land owned by DPMT following independently verified procedures. Being the current owners of the smelter, DPMT recognises that there is a reasonable responsibility to assess and address management actions in line with Government requirements. DPMT further recognises that it has a role to play in addressing immediate risks from historical contamination and therefore commissioned a detailed Contaminated Land Assessment in order to quantify these risks and identify practicable management measures.

A perched water-table and pollution plume derived from the plant, auxiliary infrastructure, and waste areas exists in certain areas of the site. These water-tables are a historical problem due to layout/design issues implemented by a number of previous owners of the smelter since the year 1905. Jones and Wagener undertook studies (JW 49/01/7818 in 2001 and JW 48/11/C391 in 2011) to investigate the contamination risks to groundwater of operations at the Tsumeb Smelter site. The investigation included subjecting samples of the slags and calcines to the Acid Rain Leach Procedure and comparing these to the Acceptable Environmental Risk levels as advocated by the South African Minimum Requirements series (DWAF, 1998). In general, these investigations found that the slags would pose a relatively low risk to groundwater, due largely to the low mobility of chemicals of concern. It has, however, been found by Ettler *et al.* (2009) that with respect to older, weathered slags such as those on the legacy slag flotation tailings dam, that complex arsenate phases can readily dissolve during the rainy season (October to March) and potentially flush significant amounts of arsenic, lead and copper into the environment in the vicinity of the slag dump. The baghouse dust and calcines were also noted to pose a significant risk to soils and groundwater and the removal of these materials to the HWDS was recommended. To date, disposal of all of the legacy baghouse dust and calcines stockpiles at the HWDS

has not been undertaken (except for a small portion of arsenic calcine waste that was disposed) and these materials continue to contribute to the contamination of groundwater. SLR's review of groundwater quality at the Tsumeb Smelter (October 2016) concluded that "It is clear that the waste storage facilities (calcines, slag, tailings and return water dams) are major sources of pollution. Monitoring results and groundwater modelling indicates that this pollution is moving off-site, to the north of the smelter and will continue to do so unless remedial action is taken".

The appropriate disposal of all arsenic calcines to the HWDS was documented as a commitment in the EMP approved by MET. This commitment has currently only partially been met and disposal of all of these wastes to the HWDS is still to be completed.

5.4 PROPOSED UPGRADE AND OPTIMISATION COMPONENTS

With additional custom concentrates available and further areas for operational improvements identified, DPMT conducted a high level investigation in 2014 to consider options for increasing the smelter capacity. This was followed by a pre-feasibility study conducted by WorleyParsons in 2015. The current proposed Upgrade and Optimisation Project was selected as the preferred option and would increase the concentrate throughput capacity from 240 000 tpa to 370 000 tpa. The new and upgraded components required in order to reach the increased throughput capacity include the following:

- Upgrading of the existing Ausmelt feed and furnace;
- Installation of a rotary holding furnace (RHF);
- Implementation of slow cooling of the RHF and converter slag;
- Upgrading of the slag mill to improve copper recovery and handle the increased tonnage from slow cooled slags;
- Option to install an additional Peirce-Smith (PS) converter; and
- Additional related infrastructure and utility upgrades (air, water and electricity supply).

The above components are described in further detail below and illustrated in the process flow diagram in Figure 5-6.

All new project components would be constructed within the current facility footprint and no greenfield areas would need to be cleared.

5.4.1 AUSMELT FEED SYSTEM AND FURNACE UPGRADES

Concentrates are received by rail car and are unloaded with an overhead clam or by truck and unloaded to separate, covered storage piles. Fluxes and remaining feed materials are received by trucks and dumped into the same covered storage area. Coal is scraped off outside the receiving bay. Revert materials from the Ausmelt furnace, converters and slag mill are also brought to this area and mixed together. The feed materials are then conveyed to a series of bins and feeders. The concentrates are blended, along with the plant reverts and fed to the Ausmelt furnace along with silica and limestone fluxes

and coal. With the proposed increased 370 000 tpa concentrate feed requirement, the concentrate and reverts feeders would need to be upgraded or replaced.

The Ausmelt furnace makes use of top submerged lance technology (TSL) and this type of furnace is sometimes referred to as a TSL furnace. For the smelting operation, air and oxygen are injected into the bath through a submerged lance to produce a 60%Cu matte plus slag. The total air and oxygen flow rate capacity of the existing lance, lance trolley piping, hoses and valve train is approximately 23,500 Nm³/h. The oxygen enrichment limitation with the existing lance is ~67% O₂ by volume. For the expanded capacity, lance flow requirement is 20,000 to 22,000 Nm³/h at ≤ 65% O₂ enrichment (by volume), which the existing lance system can achieve. The existing furnace diameter and height will be sufficient for the expanded capacity.

The Ausmelt currently has curtain cooling in the bath zone and external jacket cooling in the freeboard, uptake and down comer areas. In order to improve refractory life the furnace bath zone, freeboard, kettle, roof and bull nose will be fitted with copper coolers. The cooling load for the furnace cooling water system is expected to significantly increase. A new closed loop cooling system with pumps and heat exchangers and additional pumps on the cold side of the heat exchangers are also proposed. The existing cooling tower will require upgrading to handle the significantly increased cooling load from the copper coolers.

Varying bath levels in the Ausmelt have led to poor furnace refractory life and availability. For this reason the furnace tapping will be converted from separate slag and matte tap holes to a single continuous discharge weir. Direct tapping to the RHF (see Section 5.4.2) was not deemed suitable due to the fact that the RHF would have to be located in a pit. Therefore the matte/slag mixture from the Ausmelt will be transferred to the RHF using ladles. The matte/slag mixture will continuously overflow the Ausmelt weir and be transferred into ladles via a water-cooled tilting launder.

Tests are currently being carried out on various oxygen injection locations to optimise the efficiency of the afterburner and off-gas system while controlling uptake build-up.

The existing Ausmelt hygiene ventilation system includes two tap-hole hoods and a moveable canopy hood to service both the matte and slag ladles. For the upgraded Ausmelt the existing tapping hoods will be removed and replaced with a new hood at the weir. Design improvement of the existing moveable canopy hood for the ladles is also being considered.

5.4.2 ROTARY HOLDING FURNACE (RHF)

Matte and slag from the Ausmelt will be transferred by ladle to a new RHF with inside shell dimensions of 4.7 m (diameter) by 15.2 m (long).

Feed to the RHF would be via a stationary water-cooled tundish protruding through the south end wall of the furnace. In order to minimise the chance of spillage and rapid dumping of material into the furnace, a ladle tilter would be included to slow pour into the RHF feed tundish. The tilter is sized to provide 5 to 10 minute pour durations.

A bank of 4 to 6 porous plugs are provided in the feed end of the vessel to facilitate heat transfer from the burners in the vessel to the bath in order to reduce the amount of build-up. The plugs are supplied with nitrogen from a pressure swing adsorption plant. A 30 m³ receiver has been allowed for to provide a minimum of two hours storage of nitrogen.

Cooling water would be provided to different components within the RHF by the new closed loop cooling water circuit proposed for the Ausmelt furnace.

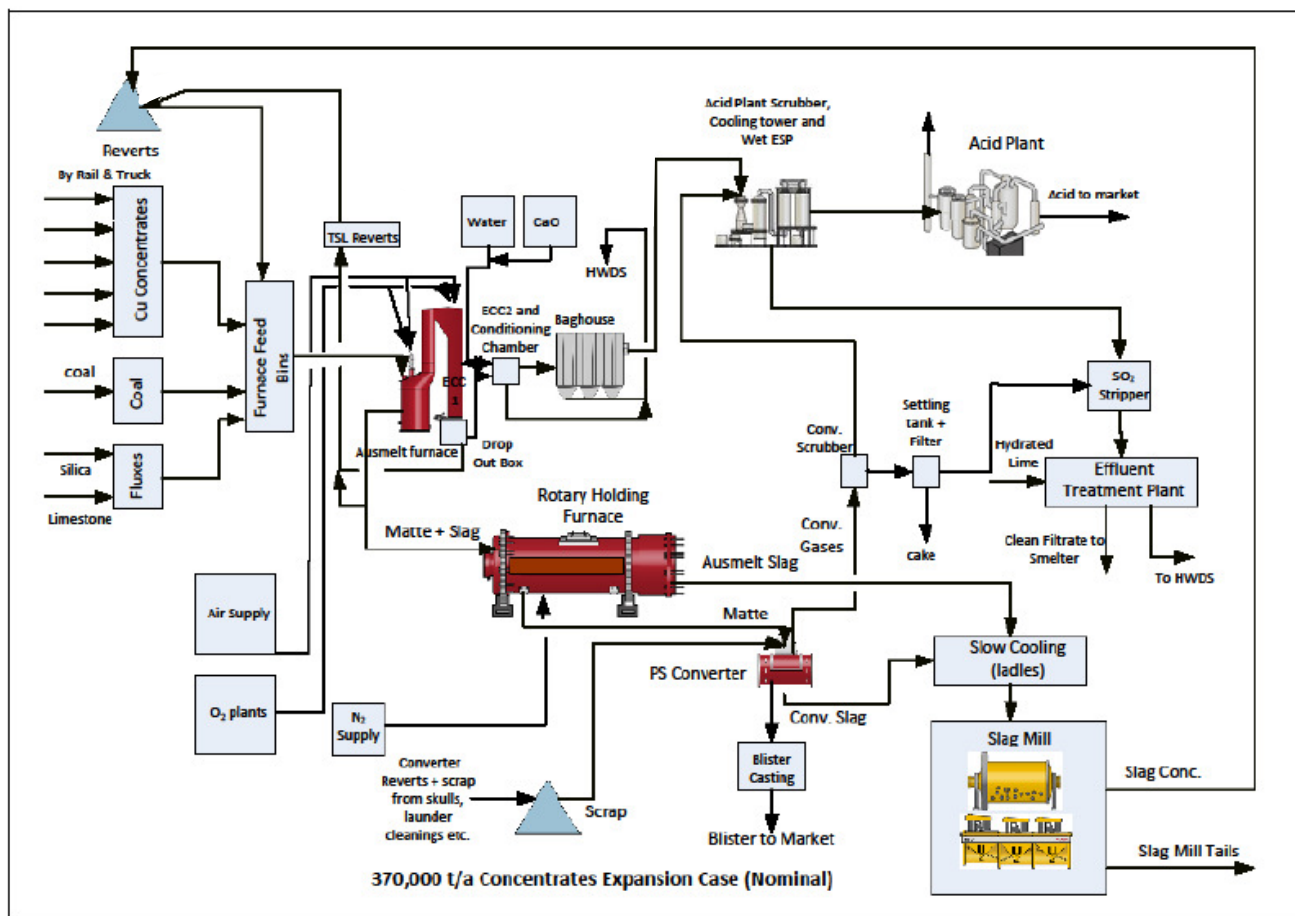


FIGURE 5-6: PROCESS FLOW DIAGRAM FOR THE EXPANDED TSUMEB SMELTER OPERATIONS. [RED AND YELLOW ITEMS INDICATE THE NEW/UPGRADED COMPONENTS SMLTED INTO THE EXISTING PROCESS STEPS] (WORLEYPARSONS, 2015)

A furnace ventilation system would be installed in order to capture off-gas from the furnace as well as gas and fume captured via hoods from the feed ladle and matte spout during pouring. Off-gas from the furnace is primarily combustion gas from the end wall and roof burners. The combustion gas would travel along the length of the furnace from the slag spout end to the feed end where it would exit through an opening in the top of the barrel. The off-gas then enters the off-gas hood, along with dilution air which lowers the mix temperature to 150 °C. The furnace ventilation system would simultaneously draw fumes from the furnace off-gassing and three different ventilation hoods. The combined gas from the three RHF ventilation hoods would be routed to a baghouse on the north side of the converter aisle. A cooling air damper

would be used to add additional cooling air (if required) to the gas stream to limit the baghouse inlet temperature to 120°C for protection of the filter bags and to ensure that any volatilized arsenic in the fume is condensed and can be collected as dust. Cleaned gas from the baghouse outlet would be drawn through two induced draft fans and discharged to the atmosphere via a new 70 m high steel stack.

A building extension is required on the north side of the converter aisle to accommodate a section of the RHF. The upper level of this extension would house an overhead service crane to lift pig iron skips and perform maintenance tasks. A nitrogen pressure swing adsorption plant would be located in a room in the upper level of the building extension. Platforms are required above and around the RHF for pig iron charging, dip bar bath level measurement, maintenance, valve racks, etc.

5.4.3 PEIRCE-SMITH CONVERTER

In order to increase the processing capacity to 370,000 tpa concentrate, the option of installing a third 13 x 30 ft Peirce-Smith converter is also considered. The addition of a third converter would allow for the other two converters to be online while the third converter could be offline for maintenance. Due to limitations on the acid plant only one converter can be blowing at a time. The third converter would be similar to the existing two converters with some differences in the flux/reverts feed system arrangement due to the plant layout. The third converter would be located on the north side of the converter aisle between the two 13 ft x30 ft converters and the new RHF.

Matte tapped from the RHF would be transferred by ladle to the Peirce–Smith converters. High grade copper scrap and some crushed ladle skulls will also be treated in the converters. Slag from the converters would be skimmed into 5.7 m³ (nominal) ladles and then transferred to the larger 12.6 m³ slag pots by the converter aisle cranes. The slag pots would then be hauled to the slag slow cooling area. Blister copper would be tapped from the converters after the copper blow and cast into billets.

Flux and reverts would be supplied to the new converter feed bins via two new inclined conveyors which would require some modification of the existing transfer tower. At the converter there is a flux feed bin and reverts feed bin. A diverter gate routes the feed to the appropriate bin. Belt feeders meter the flux and reverts onto a final feed conveyor that discharges into a feed chute that protrudes through the wall of the hood and discharges into the converter mouth.

Since only one converter will be blowing at a time, there will be no increase to the required blast air demand with the addition of the third converter.

Converter primary off-gas will be collected in a water cooled hood and will flow through a drop out chamber before going through a wet scrubber and then to the acid plant gas cleaning circuit. The wet gas from the scrubber on the third converter will tie in to the duct from the other two 13 ft x 30 ft converters leading to the acid plant cooling tower. Weak acid bleed and solids collected from the gas cleaning section will be treated in an Outotec-supplied effluent treatment plant with lime slurry at pH 12. The

treated water will go to the reclaim water pond. The gypsum from this plant is bagged and shipped to a hazardous landfill. Converter dust would be treated separately.

It is not expected that the addition of the third converter will increase the secondary gas flows to the existing hygiene system. This is due to the fact that only two of the three converters will be hot at any given time which is the design basis of the two converters being installed currently. Gas from the third converter secondary hood will be routed to the secondary gas header for the other two 13 ft x 30 ft converters.

The capacity of the cooling system would need to be increased in order to provide cooling water for the primary hood of the third converter

5.4.4 SLAG SLOW COOLING

After slow cooling, the slag pots will be brought to the crushing plant where the slag will be discharged and broken after further cooling into 20 cm size lumps to be fed to the crusher. Trials are currently underway to determine whether slow cooling will take place in pots or in pits before crushing. Slag hauling, dumping, breaking and crushing will be done by an independent contractor.

5.4.5 SLAG MILL UPGRADES

The following key changes/additions are proposed for the slag milling:

- An upgrade of the milling and classification circuits;
- Rationalization of flotation capacity by elimination of oxide rougher bank #2 and oxide cleaner cells;
- Replacement of concentrate vacuum drum filter with a 4-leaf 6ft.(1.83m) diameter disc filter;
- Addition of instrumentation in the grinding and flotation circuits and improved sampling practices to enhance metallurgical control and stability; and
- Organizational changes suggested include measures to reinforce operator training and preventative maintenance to achieve 90% slag mill availability.

5.4.6 UTILITY UPGRADES

An assessment of the existing smelter utilities and future demand requirements for the upgraded smelter was carried out by WorleyParsons (2015) as part of their pre-feasibility study for the upgrade and optimisation project. Plant air, compressed air, instrument air, oxygen, water, fuel and electricity requirements were assessed.

The assessment found that no additional capacity would be required for plant air, low pressure air or converter blast air. A new instrument air dryer would, however, be included in the smelter upgrade to accommodate the increase in demand for instrument air.

The existing high and low pressure oxygen supply would have sufficient capacity to supply the additional demand for the smelter upgrade.

The current raw water supply was found to be insufficient to meet the estimated increased demand. The pump capacity from the old mine shaft would need to be increased from 300 m³/h to 375 m³/h through the addition of a 75 m³/h raw water supply pump and 500 m pipe.

Due to the low increase in reclaim water demand at the higher throughput capacity, it is expected that the current 150 m³ storage tank would have sufficient capacity.

Light fuel oil (LFO), a mixture of diesel and recycled oils, is used for process applications within the smelter. LFO is currently stored in three tanks: an 83 m³ main storage tank, an auxiliary 7 m³ tank for the Ausmelt furnace and a 40 m³ tank located at the arsenic recovery plant. Two additional LFO supply pumps and piping are proposed for installation at the 83 m³ tank to supply the RHF and converter burners.

Heavy fuel oil (HFO) is currently stored in two main 100 m³ storage tanks and a third 20 m³ storage tank located at the arsenic recovery plant. It is proposed to install two (1+ 1 standby) additional HFO supply pumps and two (1+1 standby) HFO heaters as part of an HFO supply ring for the RHF burners.

Electricity would be supplied to the new RHF and converter from an 11 kV feed. This feed will either be a tap off an existing 11 kV line, or else will be fed from an existing line of switchgear. The 11 kV feed would supply a new 11/0.525 kV, 2500 kVA transformer, which, in turn, would power a new motor control centre (MCC). The new MCC and all required variable speed drives (VSDs) and other electrical equipment would be housed in a new electrical building to be constructed to the south of the existing HFO storage area.

5.4.7 TRANSPORT

With the proposed increase in throughput capacity of the Smelter, the transport requirements to and from Tsumeb would also increase proportionately.

The Namibian National Logistics Master Plan identifies Walvis Bay as a key component of the development of the country as an International Logistics Hub. The plan involves expanding the port and the volume of traffic through the port. The volume of heavy traffic along the road between Walvis Bay and Tsumeb is therefore likely to increase. This increase is also supported by the vision to establish Namibia as an International Logistics Hub. Therefore, while the increase in smelter production will result in an increase in the volume of heavy trucks, this increase is inevitable and is supported by the vision to develop Namibia as a logistic hub. The Master Plan also notes that the road and rail transport system does not meet international standards and identifies the need to upgrade key sections of trunk roads. Of relevance to the DPMT smelter expansion project the report recommends that the trunk roads between

Swakopmund and Karibib and between Karibib and Otjiwarongo be upgraded. These upgrades would assist in reducing potential safety concerns for road users. The Namibian Roads Authority is currently already undertaking largescale upgrades to the road between Walvis Bay and Swakopmund, which would route the majority of truck traffic around Swakopmund, further reducing the impact of increased traffic volumes on local roads from the Walvis Bay port. Ongoing maintenance of the transport route between Walvis Bay and Tsumeb is also the responsibility of the Namibian Roads Authority.

Based on the volumes transported by rail and road, it has been estimated that an additional two to five truckloads of copper concentrate would need to be transported to Tsumeb per day from Walvis Bay. It is not expected that the composition of loads to be transported to and from Tsumeb by road would differ considerably from the loads currently being transported. It is not expected that an additional two to five trucks per day on the transport route between Walvis Bay and Tsumeb would have a measurable impact on traffic accommodation on the regional road network. There would thus be no need for additional road upgrades due to the additional truck loads. The option of increasing the percentage of concentrate transported by rail would further reduce truck traffic on the regional road network.

Based on the above, the potential traffic impact will thus not be assessed further as part of this EIR. Reference is, however, made to impacts associated with transport as part of the socio-economic assessment (see Appendix H2).

5.4.8 HAZARDOUS WASTE SITE

As part of the waste management specialist report (Appendix D), calculations were performed in order to ascertain the volumes of additional hazardous waste to be produced and disposed of at the Hazardous Waste Disposal Site. A summary of the findings is provided below:

Golder, in their report, "Engineering for the Future Development and Extension of the Hazardous Waste Disposal Site" (Golder, 2015) calculated the remaining life of the HWDS for various scenarios which highlight the proposed options for continued disposal of hazardous waste to an onsite facility. Based on this and taking into consideration the waste added since 2015, the current facility has a lifespan of approximately 3.5 years (from end of May 2016). DPMT calculated that the life of the site would be 12.75 years from May 2016, assuming that the site is extended to its full capacity in line with what was previously permitted.

SLR (2016) performed further calculations to determine the remaining life as at end of June 2016. These calculations are detailed below:

Based on current waste volumes

- Airspace of existing cell as at June 2015 = 47 480 m³ (Golder, 2015)
- Airspace of remaining permitted landfill area = 153 047 m³ (DPMT, 2016)
- Volume deposited up to and including June 2016 = 8 242 m³ (DPMT records and using density of 2 tons/m³)
- Airspace available as at July 2016 = 47 480 – 8 242 = 39 238 m³
- Life of existing cell = 39 238/999 m³/month (DPMT) = **3.3 years**
- Life of entire permitted landfill area = (153 047 + 47 480 – 8 242)/999 = **16 years**

Based on future waste volumes with expansion of the facility

The proposed expansion of the facility is forecast to increase the production of end product from 240 000 tpa to 370 000 tpa (Worley Parsons, 2015), which equates to a 55% increase, commencing at the end of February 2017 (date used in calculations). Although there is likely to be some increase in efficiency, and therefore a decrease in the percentage of waste produced as a by-product, it is not possible to predict with any degree of certainty what this decrease in waste production will be and it thus has not been considered. DPMT also ceased operation of the arsenic plant which will result in an approximate 25% increase in arsenic dust generation. An increase of 80% has therefore been directly applied to the current waste generation volumes in the calculation below in order to determine the likely future volumes that will be disposed of at the Hazardous Waste Disposal Site.

Existing Cell:

- Airspace as of July 2016 = 39 238m³
- Input July 2016 to Feb 2017 = 999m³/month x 7 months = 6 993m³
- Remaining Airspace as of February 2017 = 32 245m³
- Input after Feb 2017 = 999m³/month x 80% = 1 798m³/month
- Life of Existing Cell = 7months + (32 245 / 1 798) = 18 months (or one and a half years)

Entire Permitted Landfill:

- Airspace as of July 2016 = 184 043m³
- Input July 2016 to Feb 2017 = 999m³/month x 7 months = 6 993m³
- Remaining Airspace as of February 2017 = 177 050m³
- Input after Feb 2017 = 999m³/month x 180% = 1 798m³/month
- Life of Entire Permitted Landfill = 7 months + (177 050 / 1 798) = 98.5 months (or 8 years and 2 months)

This illustrates the immediate need to begin developing the western portion of the landfill site so that once the air space in the Eastern portion is depleted DPMT can continue disposing of arsenic dust at the Hazardous Waste Disposal Site. This is based on the assumption that all arsenic waste would be disposed of at this site and that no other options for disposal are considered. DPMT is planning to soon commence with development of the second cell in line with its total approved site capacity of 201 500 m³.

DPMT are currently also investigating the feasibility of other disposal options. These include disposal to a potential future regional site in Namibia or to transport the wastes to hazardous waste sites in South Africa. DPMT are also currently investigating vitrification of the flue dust which would render it non-hazardous, and saleable, resulting in a reduction in the volume of hazardous waste to be disposed of. Further details regarding these potential alternative disposal pathways are provided in Section 3.6 of Appendix D.

5.4.9 CONSTRUCTION PHASE

5.4.9.1 SCHEDULE

It is currently anticipated that the construction period for the proposed new project components would be between 18 and 24 months.

5.4.9.2 EMPLOYMENT AND HOUSING

The total estimated construction phase employment opportunities to be created by the proposed project during the 18 month construction period would be in the order of 185 person years. This estimate does not specify the average number of people who will be employed at any given time during construction, a figure which will probably vary considerably, with more workers at some times and less at others. Most of the construction phase jobs will be in the medium skill (100 person-years) and high skill (57 person-years) categories, with 29 person-years' worth of the employment requiring people with a low level of skill. This is due to the highly technical nature of the construction.

It is anticipated that approximately 90 of these person years of work would be allocated to people from the local area and 47 to those from the rest of the Oshikoto Region. Note that these estimates are based largely on a fairly broad assessment of the availability of labour in these areas and it is DPMT's intention to use a greater proportion of labour from the local area, where possible. See Table 5-2 and Appendix H1 for further details in this regard.

TABLE 5-2: LIKELY SPREAD OF CONSTRUCTION JOBS PER AREA

	Low skill	Medium skill	High skill	Total
Anticipated % of workers from the local area	80%	50%	30%	
Corresponding number of workers	23	50	17	90
Anticipated % of workers from the rest of Oshikoto	20%	30%	20%	
Corresponding number of workers	6	30	11	47
Anticipated % of workers from the rest of Namibia	0%	20%	30%	
Corresponding number of workers	-	20	17	37
Anticipated % of workers from other countries	0%	0%	20%	
Corresponding number of workers	-	-	11	11
Total	29	99	57	185

With regards to housing, workers from outside of the local area would be accommodated within existing accommodation facilities within Tsumeb, as well as at DPMT's contractor's camps.

5.4.9.3 TRANSPORT REQUIREMENTS

Construction materials and pre-fabricated plant components would be transported by service providers to the construction site via existing smelter access and internal roads.

5.5 DECOMMISSIONING AND CLOSURE

Should the smelter operations cease in future, DPMT must ensure that adequate rehabilitation and closure of the facilities takes place following the conclusion of operations. At a conceptual level, decommissioning can be considered a reverse of the construction phase with the demolition and removal of the majority of infrastructure and activities. DPMT currently has a draft Closure Plan (Golder, 2016) that is continuously updated as operations change, additional specialist investigations are conducted and new techniques for rehabilitation are identified.

5.5.1 CLOSURE OBJECTIVES

According to DPMT's current draft Closure Plan, the main closure vision will be to *"leave a rehabilitated site behind that is physically stable, with limited residual contamination on land and in groundwater, to facilitate a wilderness end land use, largely via progressive rehabilitation during operations, within a appropriately delineated/defined buffer zone, negating intensive human use"* (in this context, 'wilderness' is defined by exclusion, i.e. land which does not qualify as wetland, arable land or grazing land). If this vision is not fully achieved and self-sustaining at closure, it will be on a well-established trajectory towards achieving a walk-away and/or positive legacy situation (Golder, 2016).

The following main closure objectives have been set:

- Physical stability: To remove and/or stabilise surface infrastructure and unavoidable mining and mineral processing residue which are present on the DPMT site to facilitate the implementation of the planned end land use;
- Environmental quality: To ensure that local environmental quality is not adversely affected by possible physical effects and chemical contamination arising from the DPMT site during the tenure of DPMT, as well as to sustain catchment yield as far as possible after closure;
- Health and safety: To limit the possible health and safety threats to humans and animals using the rehabilitated site as it becomes available;
- Land use and land capability: To re-instate suitable land capabilities over the various portions of the site to facilitate the progressive implementation of the planned land use;
- Aesthetic quality: To leave behind a rehabilitated DPMT site that, in general, is not only neat and tidy, giving an acceptable overall aesthetic appearance, but which in terms of this attribute is also aligned to the respective land uses;
- Biodiversity: To encourage, where appropriate, the re-establishment of indigenous vegetation on selected rehabilitated sites such that terrestrial ecosystems are largely re-instated over time; and
- Socio-economic mitigation: To ensure that the infrastructure transfers, if applicable, measures and/or contributions made by the facility towards the long-term socio-economic benefit of the local communities are sustainable.

The above principles and concepts will be refined as part of ongoing detailed closure planning and costing during the life of the project. Further detailed closure objectives are set out in the Consolidated EMP in Appendix K.

5.5.2 CLOSURE MEASURES

As part of the current draft Closure Plan, closure measures have been devised for the following:

- Infrastructure;
- Residue and stockpile facilities;
- Waste facilities;
- Quarries and pits;
- Contaminated land management;
- General surface rehabilitation;
- Water management, including surface water and groundwater; and
- Post closure aspects, including monitoring and after care.

6 ALTERNATIVES

DPMT has been processing complex copper concentrates at the Tsumeb Smelter since its purchase from Weatherly in 2010. The proposed Upgrade and Optimisation Project within the current facility footprint would ensure the long term efficiency and sustainability of the operations by increasing the throughput capacity to 370 000 tpa.

6.1 LOCATION ALTERNATIVES

All components of the proposed Tsumeb Smelter Upgrade and Optimisation Project would be contained within the existing facility footprint. From an environmental perspective, this would be beneficial as the overall footprint of the new components would be limited to already developed areas with no further natural areas to be disturbed. It would also not be technically or economically feasible to construct any of the new project components outside of the current facility footprint. Containing all new project components within the facility footprint would thus make environmental, technical and economic sense.

6.2 PROCESSING ALTERNATIVES

Detailed pre-feasibility studies undertaken by Berakhah (Bezuidenhout, 2014) and WorleyParsons (2015) considered a number of different options for expanding and optimising the Tsumeb Smelter operations. The current proposal was selected as the most economically feasible for expanding the processing capacity to 370 000 tpa. The pre-feasibility process and different alternatives considered prior to selecting the current proposal are described below.

With additional custom concentrates available and further areas for operational improvements identified, DPM conducted a high level scoping study in 2014 (Bezuidenhout, 2014) to look at options for increasing the smelter capacity. Five alternatives for moving forward were identified and evaluated. The alternatives considered were:

1. Spend limited capital and operate sustainably at 240 000 tpa new concentrate.
2. Construct an electric holding/ settling furnace with no extra converter (two converters only). The mass balance showed that 320 000 tpa new concentrate could be handled and that converter operation would be the next bottle neck.
3. Construct a rotary holding/ settling furnace with no extra converter (two converters only). As with Alternative 2, the mass balance showed that 320 000 tpa new concentrate could be handled and that converter operation would be the next bottle neck.
4. Construct an electric holding furnace and construct a third Peirce-Smith converter to alleviate the converting bottleneck. The mass balance showed that a throughput of 370 000 tpa new concentrate could be handled and that the Ausmelt would then limit throughput at 65% oxygen enrichment and 22 000 Nm³/h gas flow through the lance system.

5. Construct a rotary holding furnace and Peirce Smith converter. As with Alternative 4, the mass balance showed that a throughput of 370 000 tpa new concentrate could be handled and that the Ausmelt would then limit throughput at 65% oxygen enrichment and 22 000 Nm³/h gas flow through the lance system (current proposal).

Alternative 1 is very similar to the current situation and would result in the Ausmelt furnace, which has a low volume, experiencing intensive stirring. This does not allow good separation between the matte and slag resulting in excessive entrainment of matte in the slag with increased potential for pollution from the leaching of metals from the slag. Transfers of matte would be transferred to the converters on demand, as per the current operation. Since the Peirce-Smith converters cannot accept matte during the copper blow and blister casting, the capacity would be limited to 240 000 tpa. The lower throughput would result in a high fixed cost contribution on the plant. The high capital investment of the past 3 years (acid plant, oxygen plant, converters, etc.) would also contribute to a high depreciation cost per tonne. Throughput would, therefore, need to be increased in order to utilise the plant capacity optimally and to increase profitability.

Alternative 2, which involves the installation of an electric holding furnace (EHF) would allow a higher throughput, whilst recoveries would be improved and reverts (metal lock-up) would be reduced but would only result in a throughput of 320 000 tpa with converter capacity being the next bottleneck. An EHF would, however, be very costly. It also requires an open bath or partially open bath in order to avoid As and Sb reversion from the slag to the matte phase. This would require extensive cooling on the upper sidewalls and roof (which poses a risk for water leakage into the furnace) and would increase the cost of the furnace. In addition, there is the complexity of ladle transfer between the TSL and the EHF, crane utilization and scheduling of tapping of the TSL and the EHF.

Alternative 3 involves the construction of a rotary holding/ settling furnace with no extra converter and has the same advantages as Alternative 2. It, however, appears to have a better fit at the Tsumeb Smelter, mainly on financial grounds, but also because the problems associated with operating with an open bath, and tapping/ladle transfer for the EHF are avoided.

Alternatives 4 and 5 incorporate a third converter, thereby removing the bottleneck due to insufficient converting capacity, making a throughput of 370 000 tpa possible. Alternative 5 is, however, preferred on financial grounds and avoids the other problems associated with an EHF as required for Alternative 2.

A rotary furnace operation has been selected for the following reasons:

- High arsenic material feed restricts coke addition to the EHF. Less versatility to absorb reverts and converter slag feed is therefore available to DPMT. Electric furnace design and maintenance is complicated due to the required open bath operation.

- The rotary furnace can be fed directly via a weir and launder. Less handling is therefore required. Continuous tapping allows good level control in the Ausmelt, contributing to high availability.
- The mill and float circuit acts as safety net on valuable metal content lost in rotary furnace slag. The RHF presents the highest recovery option.
- The RHF option presents the lower initial capital investment.

The recommended alternative (Alternative 5) results in 370,000 tpa concentrate processing capacity which can be implemented as follows:

- Upgrade the Ausmelt to improve availability (includes copper coolers and the addition of a continuous discharge weir to stabilize the bath level in the furnace);
- Install a rotary holding furnace (RHF);
- Implement slow cooling of RHF and converter slag;
- Upgrade the TSF;
- Upgrade slag mill to improve copper recovery and handle increased tonnage from slow cooled slags; and
- Install an additional 13 x 30 ft. Peirce-Smith converter.

6.3 THE “NO PROJECT” OPTION

The financial viability and future sustainability of the Tsumeb Smelter depends on the upgrade and optimisation of current operations in order to be able to process additional available complex copper concentrates. The “No Project” option would mean that the potential increase in local and national revenue, additional employment opportunities and indirect financial spin-offs to businesses in Tsumeb would not be realised as the Tsumeb Smelter would not be functioning at an increased optimum throughput capacity.

The implementation of the project also allows for the replacement of equipment to ensure improved efficiencies from a process/financial perspective as well as from an environmental impacts perspective. Environmental impacts associated with the proposed amendments to the existing Tsumeb Smelter will be assessed cumulatively (i.e. taking the existing operations and the proposed amendments into consideration) as part of the ESIA process.

7 ENVIRONMENTAL IMPACT ASSESSMENT

7.1 INTRODUCTION

Potential environmental impacts were identified by SLR in consultation with IAPs, regulatory authorities, specialist consultants and DPMT. In the case of human-related impacts, an ESIA normally does not focus on health and safety impacts on workers because the assumption is that these aspects are separately regulated by health and safety legislation, policies and standards. As worker health was, however, identified as a concern from the public during the scoping phase, the community health and socio-economic specialist assessments made reference to worker health aspects as well (further details are provided in Appendices H and I).

The impacts are discussed under issue headings in this section. Impacts are considered in a cumulative manner where possible such that the impacts of the proposed expansion and optimisation project are seen in the context of the baseline conditions (including existing DPMT activities and facilities) described in Section 4. Information that has been included in Section 4 will not be repeated in this section.

As described in Section 5.2, the construction activities associated with the proposed expansion would be contained within the existing facility footprint. These construction activities will be similar in nature to previous construction and ongoing maintenance related activities on site and potential (additional) environmental impacts associated with most of the construction phase aspects are not regarded as significant. Therefore, the potential impacts associated with the construction facilities, activities and other construction-related issues will not be assessed for all environmental issues below.

Mitigation measures to address the identified impacts are discussed in this section and included in more detail in the consolidated EMP report that is attached in Appendix K. In most cases (unless otherwise stated), these mitigation measures have been taken into account in the assessment of the significance of the mitigated impacts only.

Both the criteria used to assess the impacts and the method of determining the significance of the impacts is outlined in Table 7-1. This method complies with the Environmental Impact Assessment Regulations: Environmental Management Act, 2007 (Government Gazette No. 4878) EIA regulations. Part A provides the approach for determining impact consequence (combining severity, spatial scale and duration) and impact significance (the overall rating of the impact). Impact consequence and significance are determined from Part B and C. The interpretation of the impact significance is given in Part D. Both mitigated and unmitigated scenarios are considered for each impact. In addition, a comment on SLR's confidence in the significance rating is provided for each impact. The confidence options range from high, to moderate to low and must be read in the context of the assumptions, uncertainties, and limitations set out in section 8.

An example, showing how the chapter has been structured is provided in Box 1 below.

BOX 1: EXAMPLE SHOWING HOW THIS CHAPTER HAS BEEN STRUCTURED

7.2 SURFACE WATER

← Environmental component heading

7.2.1 ISSUE: CHANGES IN SURFACE WATER RUNOFF

← Issue heading

Assessment of impact

Description of the issue and associated impact in terms of severity, duration, spatial scale, consequence, probability and significance – considering all phases of project including any cumulative impacts

Tabulated summary of the assessed impact

Management	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	L	M	L	M	M	M
Mitigated	L	L	L	L	L	L

Conceptual description of mitigation measures

Identification of mitigation objectives and conceptual description of mitigation actions

Emergency situation

Description of any emergency situations where relevant with reference to relevant procedures

TABLE 7-1: CRITERIA FOR ASSESSING IMPACTS

PART A: DEFINITION AND CRITERIA		
Definition of SIGNIFICANCE		Significance = consequence x probability
Definition of CONSEQUENCE		Consequence is a function of severity, spatial extent and duration
Criteria for ranking of the SEVERITY/NATURE of environmental impacts	H	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action. Irreplaceable loss of resources.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints. Noticeable loss of resources.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. Limited loss of resources.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	L	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	L	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national

PART B: DETERMINING CONSEQUENCE

SEVERITY = L

DURATION		H	Medium	Medium	Medium
	Long term	H	Medium	Medium	Medium
	Medium term	M	Low	Low	Medium
	Short term	L	Low	Low	Medium

SEVERITY = M

DURATION		H	Medium	High	High
	Long term	H	Medium	High	High
	Medium term	M	Medium	Medium	High
	Short term	L	Low	Medium	Medium

SEVERITY = H

DURATION		H	High	High	High
	Long term	H	High	High	High
	Medium term	M	Medium	Medium	High
	Short term	L	Medium	Medium	High

	L	M	H
	Localised Within site boundary Site	Fairly widespread Beyond site boundary Local	Widespread Far beyond site boundary Regional/ national

SPATIAL SCALE

PART C: DETERMINING SIGNIFICANCE

PROBABILITY (of exposure to impacts)	Definite/ Continuous	H	Medium	Medium	High
	Possible/ frequent	M	Medium	Medium	High
	Unlikely/ seldom	L	Low	Low	Medium
			L	M	H

CONSEQUENCE

PART D: INTERPRETATION OF SIGNIFICANCE

Significance	Decision guideline
High	It would influence the decision regardless of any possible mitigation.
Medium	It should have an influence on the decision unless it is mitigated.
Low	It will not have an influence on the decision.

7.2 SURFACE WATER

The information in this section was sourced from the Ground- and Surface water Specialist Input to the ESIA (SLR, 2016) (refer to Appendix D).

7.2.1 ISSUE: CHANGES IN SURFACE WATER RUNOFF

7.2.1.1 Introduction

The local drainage across the smelter site will have infrequent surface water flow during extreme rainfall events, but the catchment is already modified with existing infrastructure around the site and the area for the proposed expansion falls within the contact water section of the stormwater management system. This means that runoff water will be collected and stored on site, thus leading to a potential reduction in downstream surface water runoff.

The proposed expansion would result in additional volumes of slag material being produced, which could require additional areas to be used for disposal of this material. Mitigation measures would thus be required in order to ensure that the stormwater system capacities would be sufficient to handle any additional contact runoff generated. The proposed expansion would not change the current situation with regards to runoff potential, assuming that the stormwater system has not been spilling into the Jordan River system after previous extreme rainfall events.

There are no identified downstream surface water users between the smelter site and the Jordan River which has a limited flow for a short distance downstream. Any small reduction in the ephemeral runoff would thus not impact on any downstream water users. The currently planned stormwater management measures include a clean (non-contact) water diversion channel around the northern edge of the main smelter site in order to channel clean runoff away from the smelter site and to the Jordan River. This measure will improve the runoff from the site, as less water will flow into the smelter area and be retained in the dirty (contact) water system at the site.

Surface water runoff is largely related to operational activities, but could also increase minimally during the initial construction phase.

7.2.1.2 Assessment of impact

Severity

There is currently no significant contribution to downstream runoff from the smelter site and the severity is thus considered to be low in both the unmitigated and mitigated cases.

Duration

The duration of the potential reduction in runoff would be for the life of the project with the related impacted considered to be medium.

Spatial scale

The area of influence would extend beyond the site boundary, but not a significant distance downstream to the Jordan River. The influence is thus considered as medium in both the unmitigated and mitigated cases.

Consequence

Based on the above assessment the determining consequence is low in both the unmitigated and mitigated cases.

Probability

The probability of occurrence is low in the unmitigated case.

Significance

Summarizing the above assessment, the overall significance is rated as low in both the unmitigated and mitigated cases. SLR's confidence level is moderate to high for this significance rating.

Tabulated summary of the assessed cumulative impact - dewatering

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	L	M	M	L	L	L
Mitigated	L	M	M	L	L	L

7.2.1.3 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the consolidated EMP (Appendix K).

Objective

The objective of the mitigation measures is to ensure that no additional contact runoff is produced that could overload the stormwater management system.

Actions

- Ensure that additional slag material is appropriately stored so that it does not generate additional contact runoff.
- Upgrade sections of the stormwater system where design capacity is reached.

- Review stormwater calculations to consider increased contact water from additional slag storage.

Emergency situations

None identified for the proposed expansion.

7.2.2 ISSUE: SURFACE WATER POLLUTION**7.2.2.1 Introduction**

The main factors which could affect surface water quality are chemicals which are stored and used on the site and waste material from the smelter, as well as fuels and oils from industrial equipment.

The unmitigated impact on surface water quality was assessed assuming that the proposed improved stormwater management system has been completed. With this in place, there should be only a small likelihood of any contact water leaving the site, but with further upgrading of the stormwater system to accommodate the proposed smelter expansion, this likelihood would be reduced even further. With the implementation of recommended mitigation measures, the likelihood of polluted surface water reaching the Jordan River, approximately 1 km north of the site, would be reduced.

7.2.2.2 Assessment of impacts**Severity**

There is a possibility that polluted runoff may be transported downstream from the smelter site to the Jordan River. There is a likelihood of water quality deterioration, especially in close proximity to the smelter site. The severity for the unmitigated case is thus rated as medium, reducing to low in the mitigated case.

Duration

The duration of the potential for pollution of surface water extends beyond the life of the project and is considered as medium for both the unmitigated and mitigated cases.

Spatial scale

The area of influence stretches beyond the site boundary and possibly downstream to the Jordan River. There would, however, be some dilution effect in the Jordan River and the spatial influence is thus rated as medium for both the unmitigated and mitigated cases.

Consequence

Based on the above assessment, the determining consequence is considered to be medium in the unmitigated case and low in the mitigated case.

Probability

The probability of occurrence is medium in the unmitigated case and low in the mitigated case.

Significance

Summarising the above assessment, the overall significance is rated as medium in the unmitigated case and low in the mitigated case. SLR's confidence level is moderate for this significance rating.

Tabulated summary of the assessed cumulative impact – surface water pollution

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	M	M	M	M	M	M
Mitigated	L	M	M	L	L	L

7.2.2.3 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the consolidated EMP (Appendix K).

Objective

The objective of the mitigation measures is to ensure that any additional contact runoff from the smelter expansion does not overload the stormwater management system and that efficient management practices are implemented on the site to ensure that all potential pollution sources are contained.

Actions

- Construct additional infrastructure to manage contact water around the smelter expansion site, if required.
- Upgrade any areas of the stormwater system where the design capacity is reached.
- Ensure that possible pollution sources are stored appropriately and used safely.
- Ensure that there are no blockages of stormwater infrastructure and that contact water is efficiently contained through effective site supervision and monitoring.
- Measure the remaining extent of contaminated soil on the smelter property (in progress) and plant a shelter belt of indigenous trees or shrubs along the edges of these areas in order to prevent erosion and transport of contaminated soil into the Jordan River.
- Undertake regular sampling of runoff water and the Jordan River in order to monitor pollution levels.
- Implement phytoremediation and stabilisation of stream banks along the Jordan River in order to prevent erosion of polluted riparian soils.
- Ensure site rehabilitation is undertaken in line with the closure plan in order to remove or effectively contain polluting materials and prevent future contamination of runoff from the site.

Emergency situations

None identified for the proposed expansion.

7.3 GROUNDWATER

The information in this section was sourced from the specialist groundwater assessment in Appendix D.

7.3.1 ISSUE: GROUNDWATER QUANTITY**7.3.1.1 Introduction**

The only activities that have the potential to reduce the local groundwater level is a significant increase in water abstraction due to the increase in throughput capacity of the smelter that could amplify the cone of depression caused by pumping of groundwater. This can have the following potential impacts on the hydrogeology of the area surrounding the Smelter Complex, that are considered in the assessment below:

- Lowering of groundwater levels and reduction in aquifer supply
- Declining yield in existing 3rd party boreholes due to declines in water levels.
- Impacts on groundwater dependent ecosystems.

Groundwater abstraction is largely related to operational activities, but could also increase during the initial construction phase (although minimal additional water required for construction).

7.3.1.2 Assessment of impact**Severity**

Increased abstraction of groundwater for the expansion could cause a local cone of depression at the abstraction boreholes and the shaft. Current abstraction, however, does not show a measurable impact and indications are that no significant abstraction increase is planned for the expansion project.

Duration

The duration of the potential for a significant cone of depression forming would be for the life of the facility, but causing a low impact.

Spatial scale

According to the groundwater models, the spatial scale does not extend beyond the facility boundary fence, therefore there would be a low influence in both the unmitigated and mitigated cases.

Consequence

Based on the above assessment the determining consequence is low in both the unmitigated and mitigated cases.

Probability

The probability of occurrence is medium in the unmitigated case. A radius of influence is likely but could not be detected due to the lack of monitoring. With mitigation, the impact probability is reduced to low.

Significance

Summarizing the above assessment, the overall significance is rated as medium in the unmitigated scenario reducing to low in the mitigated scenario. SLR's confidence level is moderate to high for this significance rating.

Tabulated summary of the assessed cumulative impact - dewatering

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	L	L	L	L	M	M
Mitigated	L	L	L	L	L	L

7.3.1.3 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the consolidated EMP (Appendix K).

Objective

The objective of the mitigation measures is to reduce the impact of the cone of depression caused by groundwater abstraction.

Actions

- Monitor water levels in boreholes on the smelter site and offsite (including the Tsumeb Municipality and Ministry of Agriculture, Water and Forestry monitoring and production boreholes) in order to monitor possible cones of depression caused by pumping water from Shaft 1.
- Monitoring results are to be used in future groundwater model updates.
- Develop a dynamic water balance model for the site to inform future remedial action.
- Obtain a groundwater abstraction permit from the Ministry of Agriculture, Water and Forestry, if required.

Emergency situations

None identified for the proposed expansion.

7.3.2 ISSUE: GROUNDWATER QUALITY

7.3.2.1 Introduction

The assessment found that groundwater quality could potentially deteriorate as a result of the proposed expansion project based on modelled data. Based on measured data for heavy metal and sulphate concentrations, the baseline groundwater quality before the proposed expansion indicates that the smelter site has already impacted significantly on groundwater quality on site. Modelling data showed that polluted groundwater could potentially migrate offsite. The expansion could potentially increase this modelled impact, though not significantly higher than what may already be experienced. Contamination plume modelling from 2013 and 2016 groundwater reports by GCS indicate that arsenic concentrations are elevated offsite and the plume is likely to continue to move to the north, potentially eventually impacting on irrigation boreholes if no action is taken to prevent this.

The groundwater impact assessment includes a review of previous groundwater reports and the groundwater model (refer to Appendix D). It must be noted that the accuracy of the current groundwater model and thus extent of the predicted contamination plume (up to the year 2038) has been brought into question as part of the current groundwater impact assessment. In the absence of an updated groundwater model, the below assessment is, however, still based on the long-term assumptions based on modelled data in the latest groundwater reports.

7.3.2.2 Assessment of impacts

Severity

The latest groundwater model based on water quality measured on the smelter site found that contaminated groundwater may be moving offsite as a result of the smelter operations and is likely to continue. It is, however, not expected that the proposed expansion project would contribute significantly to the current groundwater impacts. In the unmitigated case, the severity of the impacts currently being experienced is considered as high. In the mitigated case, the severity can be reduced to medium, since the Group B water quality limit could be reached with the implementation of mitigation measures. As the impact is already being experienced, the impact of the proposed expansion on groundwater quality is assessed as cumulative.

Duration

The duration of potential ground water pollution extends beyond the life of the project and is thus considered as high for the unmitigated case and medium for the mitigated case, since remedial action could reduce the period of impact.

Spatial scale

Groundwater modelling showed that polluted groundwater could spread far beyond the site boundary as contamination transport is expected to follow the groundwater flow patterns. A high rating is thus assigned to both the unmitigated and mitigated cases with regard to spatial scale.

Consequence

Based on the above assessment, the determining consequence is considered to be high in the unmitigated case and medium in the mitigated case.

Probability

The probability of occurrence is high in the unmitigated case and medium in the mitigated case.

Significance

Summarizing the above assessment, the overall significance is rated as high in the unmitigated case and medium in the mitigated case. SLR's confidence level is moderate for this significance rating.

Tabulated summary of the assessed cumulative impact – groundwater pollution

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	H	H	H	H	H	H
Mitigated	M	M	M	M	M	M

7.3.2.3 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the consolidated EMP (Appendix K).

Objective

The objective of the mitigation measures is to reduce the offsite spread of contaminated groundwater.

Actions

- Refine the current groundwater model in order to make accurate predictions of groundwater flow.
- Complete the study on sources of contamination and potential remedial action (currently only in a planning stage with scope of work developed with the intention of tendering the work out in 2017).
- Investigate targeted solutions for groundwater treatment and pollution source elimination in order to reduce potential offsite pollution. Also consider an increase in the number of recovery boreholes.
- Rehabilitate polluting dumps in line with the closure plan recommendations.
- Dispose of waste material at a suitable disposal site. This would require the establishment of a formal waste site or addition of incinerator for the additional waste volumes to be generated.

- Implement the phytoremediation trials in line with the closure plan.
- Drill additional monitoring boreholes offsite in the downgradient direction and into different geological / hydrogeological environments.
- Include regional groundwater monitoring from existing farm and municipal boreholes and produce a detailed groundwater monitoring schedule.
- Regularly sample monitoring boreholes in order to timeously identify changes in groundwater quality.

Emergency situations

None identified for the proposed expansion.

7.4 AIR QUALITY

The information in this section was sourced from the air specialist study in Appendix F (Airshed, 2017).

7.4.1 Introduction

As stated in Section 4.6, there have been notable decreases in air emissions from smelter operations during 2016. Decreases in SO₂ and PM₁₀ levels in 2016 can be ascribed to the commissioning of the sulphuric acid plant and decommissioning of the reverberatory furnace.

As the Namibian Atmospheric Pollution Ordinance (No. 11 of 1976) does not include any ambient air quality standards, interim World Health Organisation (WHO) guidelines and South African National Ambient Air Quality Standards (NAAQS) were considered in the assessment of air quality impacts. The guidelines and standards used for SO₂ and PM₁₀ in the assessment are set out in Table 7-2.

TABLE 7-2: ASSESSMENT GUIDELINES AND STANDARDS CONSIDERED IN THE ASSESSMENT

Pollutant	Averaging (exposure period)	Limit value (µg/m ³)	Limit value (ppb)	Limit value reference	Permitted frequency of exceedance	Reference
PM ₁₀	24-hour	75	Not applicable	WHO IT-3 and SA NAAQS	4	WHO and SA NAAQS
	1-year	40	Not applicable	SA NAAQS	-	-
SO ₂	10-minute	500	191	SA NAAQS	526	SA NAAQS
	1-hour	350	134	SA NAAQS	88	SA NAAQS
	24-hour	125	48	WHO IT-1 and SA NAAQS	4	SA NAAQS
	1-year	50	19	SA NAAQS	-	-

For the potential health impacts associated with non-criteria pollutants, arsenic and H₂SO₄, guidelines of the California Environmental Protection Agency (CALEPA) and WHO were used. The CALEPA guidelines were used in the absence of Namibian, South African and specific WHO standards for these

pollutants. The CALEPA guideline was considered as the latest and most stringent for use in the assessment. Chronic and acute inhalation criteria and unit risk factor (URF) (applicable to pollutants with a carcinogenic impact) for arsenic and H_2SO_4 considered in the assessment are set out in Table 7-3. Increased lifetime cancer risk was calculated by applying the URF to predicted long term (annual average) pollutant concentrations. The qualitative ranking of cancer risk estimates as per the New York State Department of Health (NYSDOH) was used in the assessment to provide a qualitative description of the excess lifetime cancer risk associated with arsenic exposure (see Table 7-4).

TABLE 7-3: CHRONIC AND ACUTE INHALATION SCREENING CRITERIA AND CANCER UNIT RISK FACTORS

Pollutant	Chronic Screening Criteria ($\mu\text{g}/\text{m}^3$)	Acute Screening Criteria ($\mu\text{g}/\text{m}^3$)	Inhalation URF ($\mu\text{g}/\text{m}^3$) ⁻¹
Arsenic	0.015 (CALEPA)	0.2 (CALEPA)	1.5E-03 (WHO)
H_2SO_4	1 (CALEPA)	120 (CALEPA)	Not applicable

TABLE 7-4: EXCESS LIFETIME CANCER RISK (AS APPLIED BY NYSDOH)

Risk Ratio	Qualitative Descriptor
Equal to or less than one in a million	Very low
Greater than one in a million to less than one in ten thousand	Low
One in ten thousand to less than one in a thousand	Moderate
One in a thousand to less than one in ten	High
Equal to or greater than one in ten	Very high

Dispersion models were used to predict spatial air quality concentrations for the operational phase, based on an increased processing rate of 370 000 t/a. The results for the measured emissions are summarised below. Dispersion modelling for the construction and decommissioning phases was considered to be unrepresentative of the actual activities that will result in dust and gaseous emissions, due to the overly conservative emission rate calculation and was thus not assessed separately.

SO₂

It is expected that SO₂ emissions will increase most notably because of the introduction of the RHF where SO₂ will be released during charging and pouring.

In order to determine the dispersion of SO₂ from the smelter as a result of the proposed expansion, SO₂ concentrations were simulated at ambient air quality monitoring locations. As the sulphuric acid plant conversion efficiency rate was on average at 76% during 2016, a 76% efficiency rate was used in the simulations. The 76% efficiency rate is considered to be a worst case scenario and it is expected that the acid plant would reach between 90 and 95% efficiency rate on average. The 53% increase in SO₂ emissions from the smelter is expected to result in similar increases in ambient SO₂ concentrations. The simulation results showed that SO₂ concentrations associated with the proposed plant expansion, would

exceed the South African 1-year average assessment criterion of $50 \mu\text{g}/\text{m}^3$ at the Sewerage Works ($123 \mu\text{g}/\text{m}^3$) and eastern parts of Tsumeb (see Figure 7-1). The 24-hour average criterion (4 days of exceedance of $125 \mu\text{g}/\text{m}^3$) is exceeded at the Sewerage Works ($304 \mu\text{g}/\text{m}^3$) and most of Tsumeb (see Figure 7-2). The 99th percentile of 1-hour average concentrations (equivalent to the 88th highest hour) exceeds the adopted criterion of $350 \mu\text{g}/\text{m}^3$ (or 88 hours of exceedance of $350 \mu\text{g}/\text{m}^3$) across Tsumeb.

As mentioned above, in 2016 the average conversion efficiency of the sulphuric acid plant was 76%. It was calculated that an efficiency rate of 95% would be required to ensure that ambient SO_2 levels remain within the adopted SO_2 assessment criteria (see Figures 7-3 and 7-4). Since commissioning of the plant towards the end of 2015, the plant performed at its best in May 2016 when a conversion efficiency of 90% was reached.

PM₁₀

The proposed increased throughput capacity is expected to increase both long and short term ambient PM_{10} concentrations by a factor of approximately 1.2. Simulated levels associated with the proposed upgrade project do, however, not exceed PM_{10} air quality limits off-site (see Figure 7-5 and 7-6).

Arsenic

Simulations for the current 240 000 t/a operating conditions showed that 1-year average arsenic concentrations exceed the CALEPA (California Environmental Protection Agency) chronic inhalation reference concentration of $0.015 \mu\text{g}/\text{m}^3$ off-site. These simulated annual average levels at the complex boundary were found to be comparable to annual means reported for arsenic at the Plant Hill and Sewerage Works monitoring stations in 2016. It was found that furnace building fugitives (fumes escaping primary and secondary capture systems) contribute most notably to these off-site arsenic impacts.

Modelled ground level ambient arsenic levels could potentially increase by approximately 54% due to the proposed upgrade project (see Figure 7-7). The increase is attributed to the assumption that furnace building fugitive emissions will increase linearly with increased production rates. The contribution of additional arsenic emissions from the proposed RHF to ground level arsenic concentrations is, however, minimal. Efforts should therefore be made to reduce building fugitive emissions through suitable and effective engineering controls (see recommended actions under Section 7.4.2.1 below and further details in Appendix F).

Increased lifetime cancer risk was determined by applying the WHO URF of $0.0015 \mu\text{g}/\text{m}^3$ to 1-year average concentrations. Whereas increased lifetime cancer risk at the facility boundary is classified as “moderate” per the NYSDOH scale, the increased lifetime cancer risk at Tsumeb town is “low” for both the current and increased throughput capacity (see Figure 7-8).

Given the above, the impact of arsenic on the receiving environment and nearby AQSRs at Ondundu is at the upper level of what might be considered acceptable both from a non-carcinogenic and carcinogenic inhalation health exposure perspective. It is essential that attention be paid to the reduction of arsenic-containing dust emissions, especially the handling and disposal of such dust at the hazardous waste disposal site post-closure of the arsenic plant.

H₂SO₄

For sulphuric acid, dispersion from the acid plant stack was simulated. Ambient H₂SO₄ levels are expected to increase by a factor of 1.4 due to the proposed increased throughput capacity. Both 1-year and 1-hour average off-site concentrations were, however, found to be well within ambient air quality limits (see Figures 7-9 and 7-10).

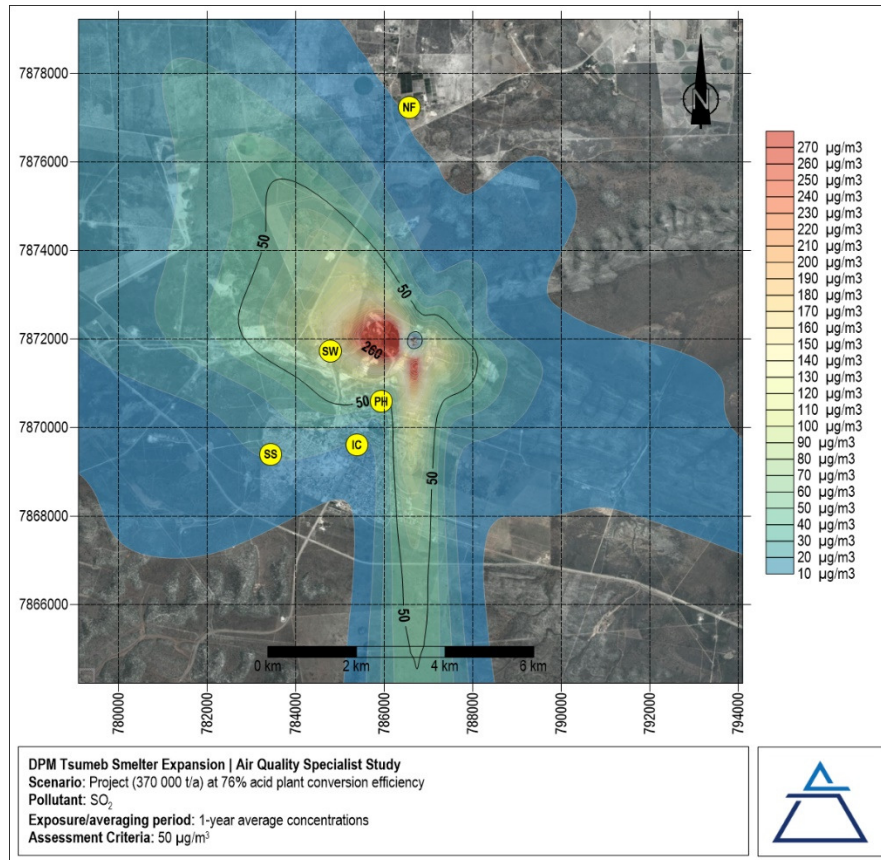


FIGURE 7-1: SIMULATED 1-YEAR AVERAGE SO₂ CONCENTRATIONS AT 76% ACID PLANT CONVERSION EFFICIENCY

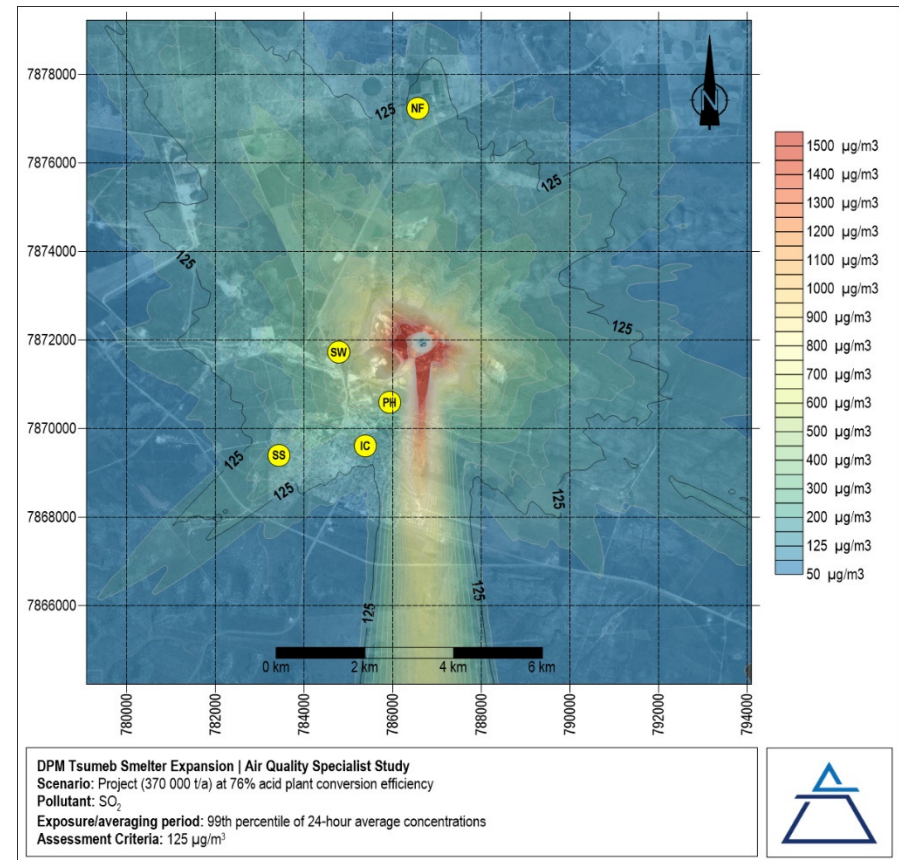


FIGURE 7-2: 99th PERCENTILE OF SIMULATED 24-HOUR AVERAGE SO₂ CONCENTRATIONS AT 76% ACID PLANT CONVERSION EFFICIENCY

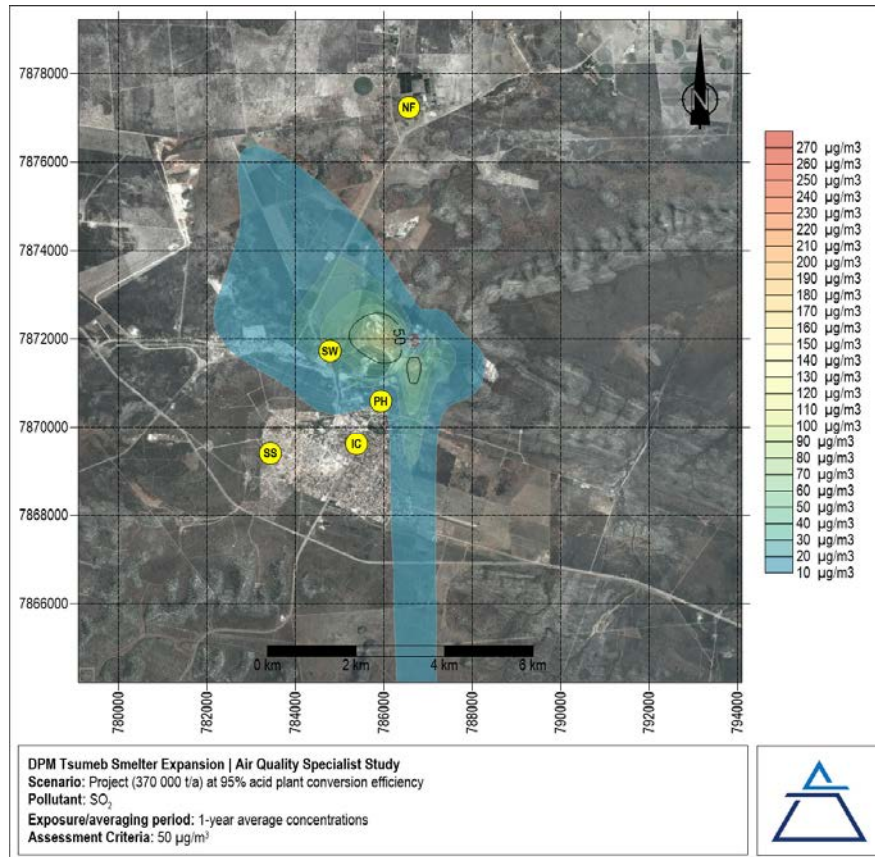


FIGURE 7-3: SIMULATED 1-YEAR AVERAGE SO₂ CONCENTRATIONS AT 95% ACID PLANT CONVERSION EFFICIENCY

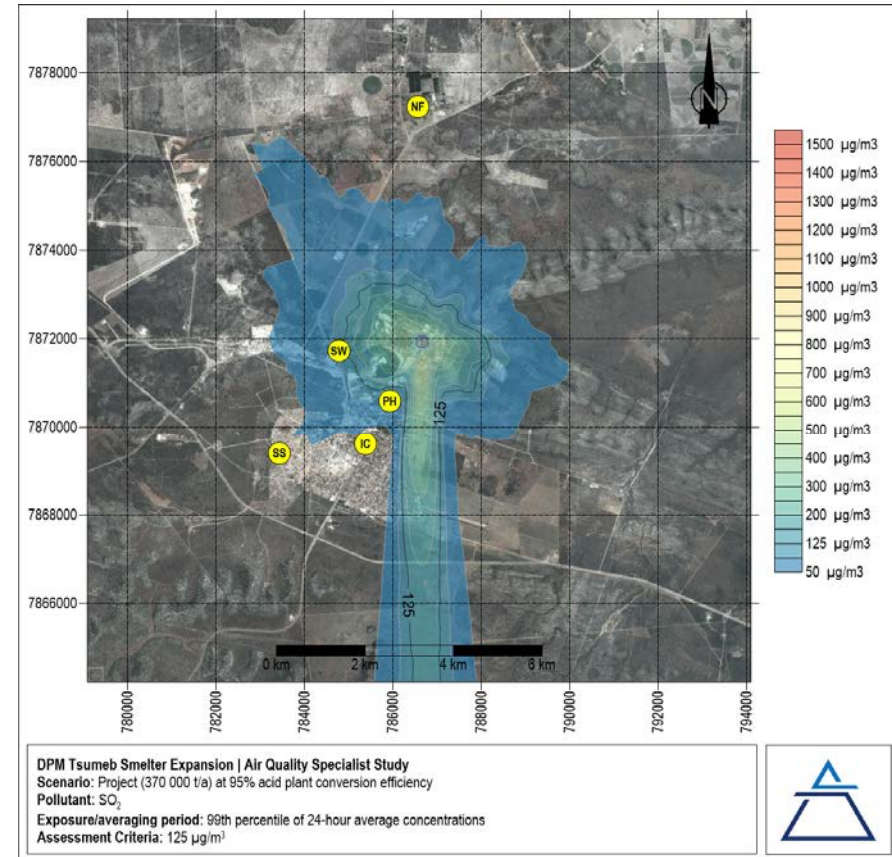
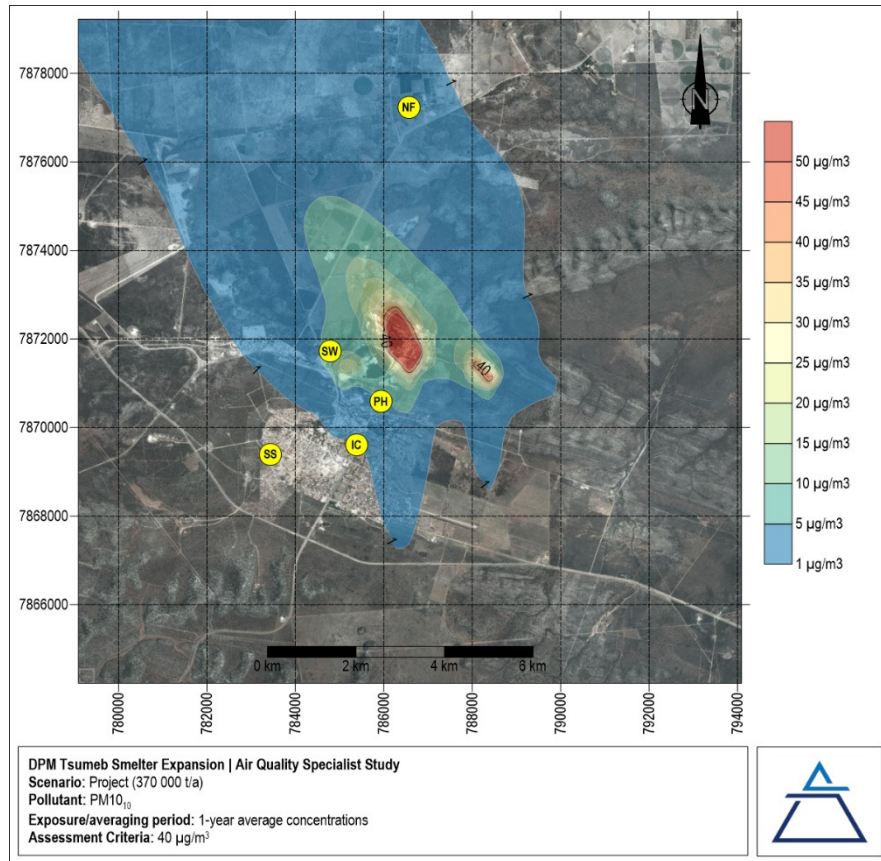
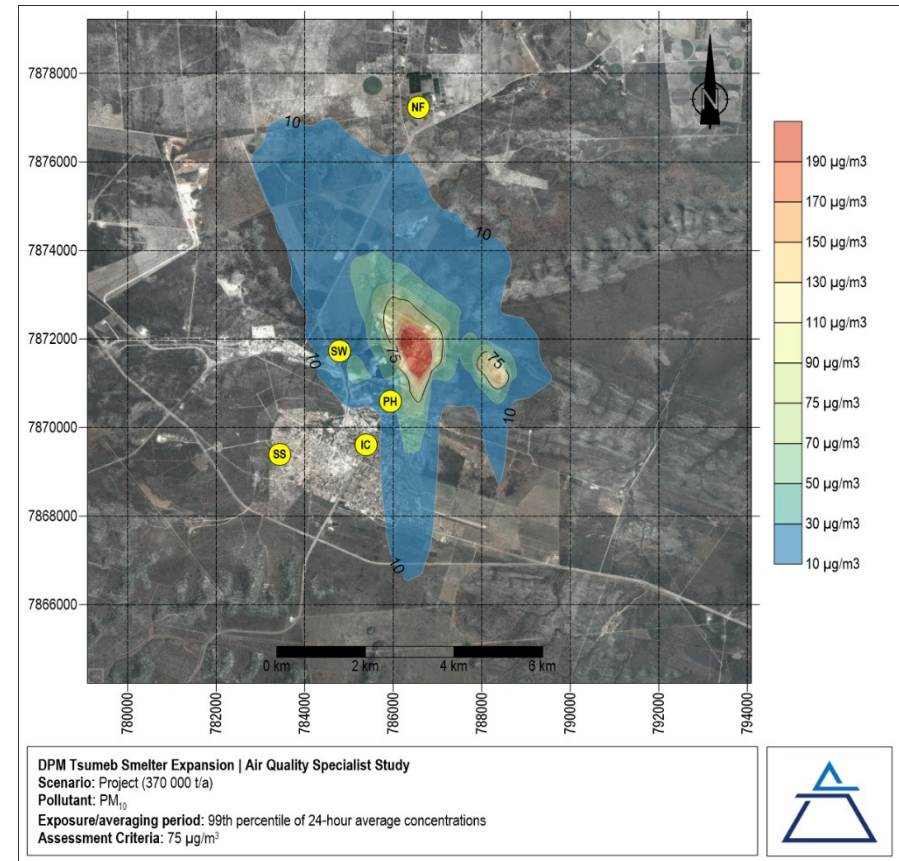


FIGURE 7-4: 99th PERCENTILE OF SIMULATED 24-HOUR AVERAGE SO₂ CONCENTRATIONS AT 95% ACID PLANT CONVERSION EFFICIENCY

FIGURE 7-5: SIMULATED 1-YEAR AVERAGE PM₁₀ CONCENTRATIONSFIGURE 7-6: 99th PERCENTILE OF SIMULATED 24-HOUR AVERAGE PM₁₀ CONCENTRATIONS

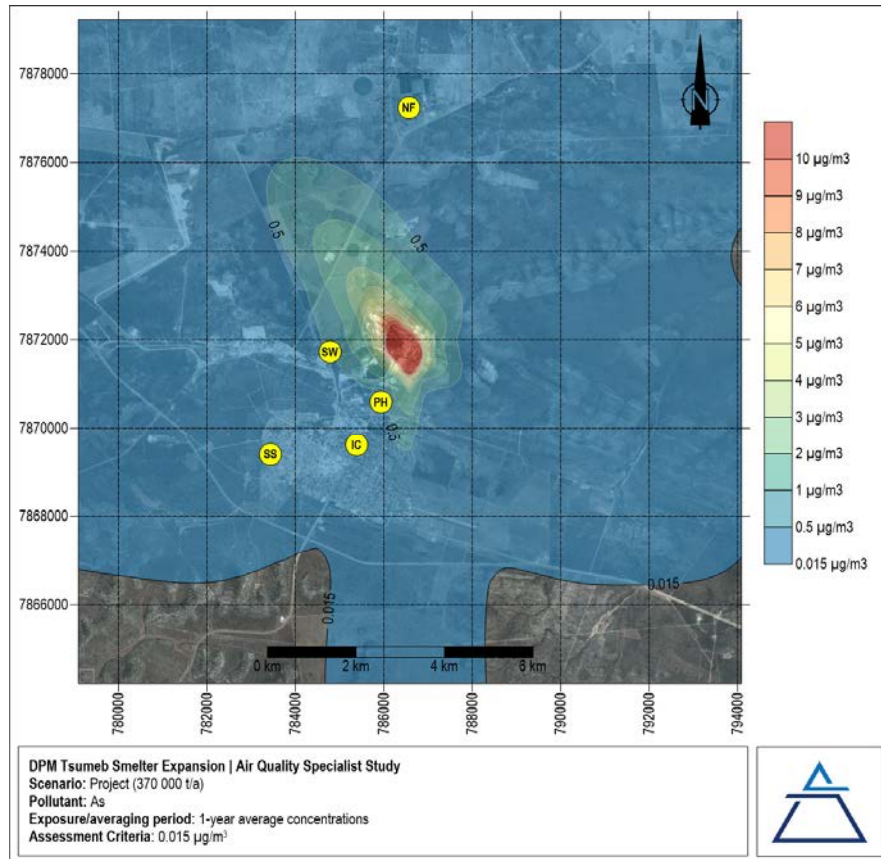


FIGURE 7-7: SIMULATED 1-YEAR AVERAGE ARSENIC CONCENTRATIONS

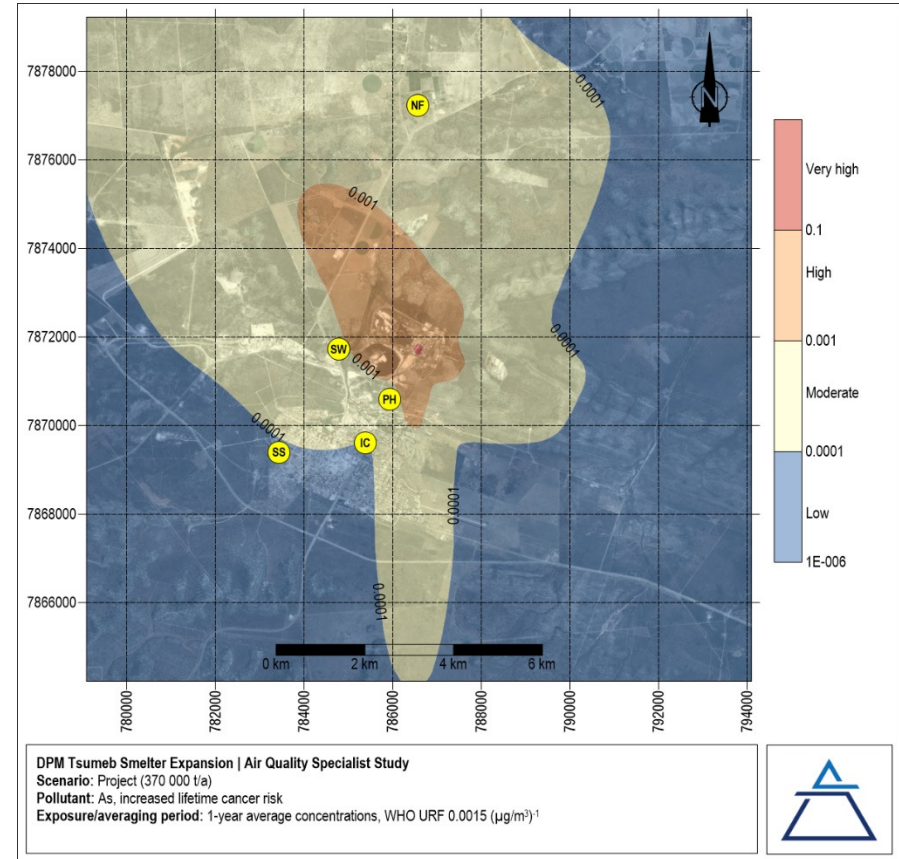
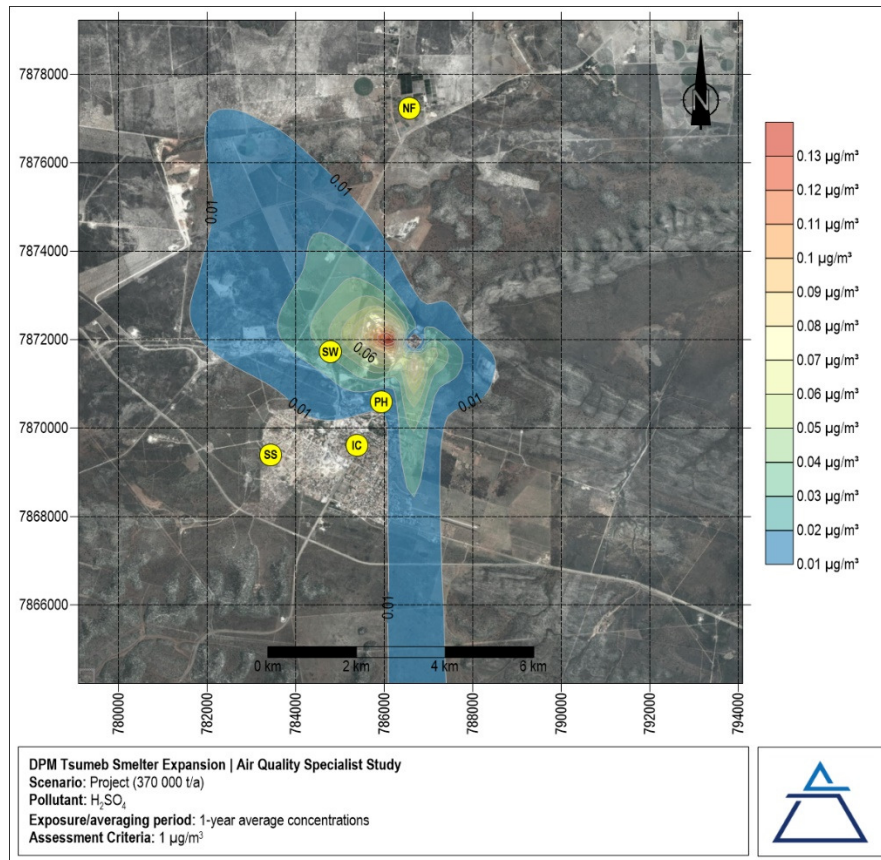
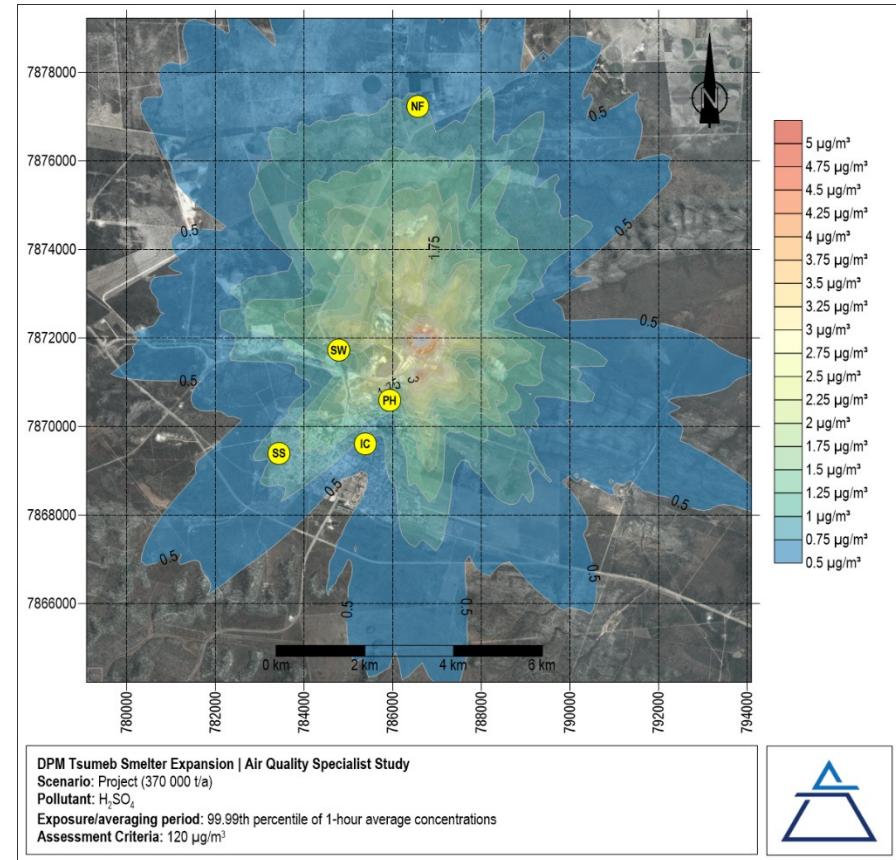


FIGURE 7-8: INCREASED LIFETIME CANCER RISK ASSOCIATED WITH ARSENIC INHALATION EXPOSURE

FIGURE 7-9: SIMULATED 1-YEAR AVERAGE H_2SO_4 CONCENTRATIONSFIGURE 7-10: 99th PERCENTILE OF SIMULATED 1-HOUR AVERAGE H_2SO_4 CONCENTRATIONS

7.4.2 Assessment of impact

Severity

During the operational phase of the proposed upgrade and optimisation project, SO₂ emissions will increase most notably because of the introduction of the RHF where SO₂ will be released during charging and pouring. PM₁₀, arsenic and H₂SO₄ emissions will increase mostly because of increased material throughput and production rates. The increase is expected to be proportional to the increase in the concentrate processing rate.

Regardless of the expected emission increases, dispersion simulations indicated no exceedances of air quality limits or screening criteria for PM₁₀ and H₂SO₄ off-site due to the increased throughput capacity.

Although a significant decrease in ambient SO₂ levels have been recorded after commissioning of the sulphuric acid plant, DPMT is still in the process of optimising the plant to reach higher conversion efficiencies and exceedances of SO₂ assessment criteria are thus still currently being exceeded. Based on a 76% sulphuric acid plant conversion efficiency, dispersion simulations indicated that short-term (24-hour and 1-hour) screening criteria for SO₂ is still expected to be exceeded at the AQSRs in Tsumeb with the proposed increased throughput capacity.

Simulated arsenic concentrations, both on and off-site, exceed chronic screening criteria, comparable with 2016 measurements from the site boundary monitoring stations (Plant Hill and Sewerage Works). Increased lifetime cancer risk at Tsumeb town indicated low risk (between one in a million and one in ten thousand) because of arsenic exposure through the inhalation pathway. The impact of arsenic on the receiving environment and nearby AQSRs was found to be at the upper level of what might be considered acceptable, from a non-carcinogenic and carcinogenic inhalation health exposure perspective (see Section 7.7 for a detailed assessment of community health risks).

Based on the above findings, the severity of the potential health risk to AQSRs in the Tsumeb area due to the proposed increased throughput capacity of the smelter is considered to be medium, since exceedance of the assessment criteria at AQSRs would occur given current performance levels of the sulphuric acid plant and fugitive emissions management systems. With mitigation, impact severity may be reduced to low-medium.

Duration

The duration would be for the life of the project and is considered medium term in both the unmitigated and mitigated scenarios.

Spatial scale

The spatial scale of the potential cumulative impact is directly related to the spatial scale of the dispersion of any air pollution that in turn has the potential to impact on human health. Impacts would be experienced on a local scale. The rating is considered medium without mitigation and low-medium with mitigation.

Consequence

Based on the above assessment, the consequence is medium in the unmitigated scenario and low-medium in the mitigated scenario.

Probability

The probability of occurrence of the impact is considered definite and the rating is thus high for both scenarios.

Significance

Summarising the above assessment, the overall significance is rated as medium. After mitigation, the significance would reduce to low-medium.

Cumulative impacts

The assessment of the increased throughput capacity is considered to be cumulative to current operational impacts.

Tabulated summary of the assessed cumulative impact – air quality impacts

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	M	M	M	M	H	M
Mitigated	L-M	M	L-M	L-M	H	L-M

7.4.2.1 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the Consolidated EMP (Appendix K).

Objective

The objective is to minimise impacts to AQSRs by ensuring ambient air quality limits are not violated off-site.

Actions

- The RHF baghouse stack must be at least 70 m high (at a release height of 70 m, emissions released will result in ground level pollutant levels of no more than 25% of the ambient air quality limits);
- The fume capture and extraction systems at the RHF must be maintained and operated to specifications to ensure minimal fugitive emissions during charging, holding and pouring cycles;
- Improve fugitive dust management measures to minimise PM₁₀ and arsenic emissions which will increase proportionally to increased production rates. Specific measures must include the following:
 - Proper handling and disposal of arsenic containing dusts at the hazardous waste disposal site;
 - Good housekeeping on plant and road areas to reduce fine material re-entrainment by wind and vehicles; and
 - Enclosure, extraction and fabric filters on slag plant crusher section.
- The sulphuric acid plant conversion efficiency is to be improved from 76% to 95%.
- Undertake continuous monitoring of SO₂ emissions released through the acid plant stack. This will enable plant operators to monitor plant efficiency and provide a true reflection of SO₂ emissions over time.
- Implement additional management measures and monitoring systems as detailed in the Consolidated EMP (see Appendix K).

Emergency situations

None identified.

7.5 NOISE

The information in this section was sourced from the noise specialist study in Appendix G (Airshed, 2017).

7.5.1 Introduction

Noise Sensitive Receptors (NSR) generally include places of residence and areas where members of the public may be affected by noise generated by industrial activities. The closest NSRs to the smelter complex include the town of Tsumeb and its suburbs to the south and southwest, as well as farmsteads.

The main meteorological parameters affecting the propagation of noise include wind speed, wind direction and temperature. These along with other parameters such as relative humidity, air pressure, solar radiation and cloud cover affect the stability of the atmosphere and the ability of the atmosphere to absorb sound energy. For the purpose of this assessment, use was made of recorded on-site data

(15 September 2016 when the plant was offline and 5 to 6 October 2016 when the plant was fully operational) as presented in Appendix G.

Upgrades proposed as part of the expansion will add additional sources of noise. The installation of the new RHF, its feed, fuel and mechanical systems as well as off-gas extraction, cleaning and venting systems will result in localised noise level increases. The increase in overall processing and production rates will also affect noise levels because of more frequent vehicle trips, increased material handling rates etc.

A noise impact assessment was undertaken in order to investigate the potential for annoyance as a result of increased noise levels.

The assessment referred to the following guidelines and criteria:

The IFC General Environmental Health and Safety Guidelines on noise address impacts of noise beyond the property boundary of the facility under consideration and provides noise level guidelines. The IFC states that noise impacts should not exceed the levels presented in Table 7-5, or result in a maximum increase above background levels of 3 dBA at the nearest receptor location off-site. For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. $\Delta = 3$ dBA is, therefore, a useful significance indicator for a noise impact.

TABLE 7-5: IFC NOISE LEVEL GUIDELINES

Area	One Hour L_{Aeq} (dBA) 07:00 to 22:00	One Hour L_{Aeq} (dBA) 22:00 to 07:00
Industrial receptors	70	70
Residential, institutional and educational receptors	55	45

SANS 10103 also provides a useful guideline for estimating community response to an increase in the general ambient noise level caused by intruding noise. If Δ is the increase in noise level, the following criteria are of relevance:

- $\Delta \leq 0$ dB: There will be no community reaction;
- $0 \text{ dB} < \Delta \leq 10$ dB: There will be 'little' reaction with 'sporadic complaints';
- $5 \text{ dB} < \Delta \leq 15$ dB: There will be a 'medium' reaction with 'widespread complaints'. $\Delta = 10$ dB is subjectively perceived as a doubling in the loudness of the noise;
- $10 \text{ dB} < \Delta \leq 20$ dB: There will be a 'strong' reaction with 'threats of community action'; and
- $15 \text{ dB} < \Delta$: There will be a 'very strong' reaction with 'vigorous community action'.

The categories of community response overlap because the response of a community does not occur as a stepwise function, but rather as a gradual change.

Due to the most notable noise levels being related to operational activities of the smelter, it is expected that additional noise impacts during the construction and decommissioning phases would be minimal and was thus not assessed separately.

7.5.2 Assessment of impact

Severity

Based on the main meteorological parameters, it is expected that noise impacts would on average be most notable to the northwest and south of the smelter facility.

The noise study findings showed that the only NSR where activities from the smelter complex were audible was the farmstead on the property of Mr Danie Potgieter, approximately 650 m northwest of the smelter boundary and 600 m east of the M75 road. It was found that noise levels in the town are greatly affected by community activities and highly dependent on wind speed.

Noise simulations indicated that the proposed increased throughput capacity would not result in exceedances of noise levels guidelines at NSRs. The increases in noise levels above the measured background level of 44.8 dBA during the day and 39.4 during the night are less than 3 dBA at all NSRs.

Presently, residents on the farm of Mr Potgieter and close to the Tsumeb Private hospital are able to hear smelter activities under calm wind conditions and especially at night. The increases in noise levels are, however, less than 3 dBA and not sufficiently higher as to result in annoyance.

The simulated overall increase in noise levels from the proposed increased throughput capacity is less than 1 dBA. Since, for a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable, it is unlikely that NSRs will be affected by the expansion project from an environmental noise perspective.

Additional simulations were included to assess the impact noise from the No. 2 oxygen plant during its start-up cycle. Simulations indicate that residents on the farm of Mr Potgieter are exposed to noise levels that are close to the night-time noise level guideline of 45 dBA. At day and night-time background levels of 44.8 dBA and 38.4 dBA, the plant will result in an increase of 2.9 dBA during the day and 6.6 during the night. According to SANS 10103 'little' to 'medium' reaction with 'sporadic complaints' to 'widespread complaints' can be expected. Although not considered part of normal operating conditions, it is essential that noise from this plant be addressed to improve the overall acoustic performance of the smelter complex.

Based on the above, the severity is considered low, with no exceedances of noise level guidelines at NSRs outside the smelter boundary.

Duration

Duration would be for the life of the project and is thus considered medium term.

Spatial scale

Noise impacts will be localised in both the unmitigated and mitigated scenarios. This is a low spatial scale.

Consequence

Based on the above assessment, the consequence of potential noise impacts is low.

Probability

The probability of the noise levels exceeding the criteria at any of the receptors is low. Whether this results in a negative impact will depend on the expectations of the third parties and their response to the audible noise. The related probability is assumed to be low.

Significance

Summarising the above assessment, the overall significance is rated as low in both the unmitigated and mitigated scenarios.

Tabulated summary of the assessed cumulative impact – noise impacts

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	L	M	L	L	L	L
Mitigated	L	M	L	L	L	L

Note that the significance of impacts during the start-up of the No. 2 oxygen plant is considered medium. With the implementation of mitigation measures, the significance will be reduced to low.

7.5.3 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the Consolidated EMP (Appendix K).

Objective

The objective of the measures is to minimise the impact on NSRs by ensuring that noise level guidelines are not violated.

Actions

- The silencer on the outlet of the No. 2 oxygen plant must be replaced or maintained;
- Record and respond to complaints by conducting regular noise monitoring;

- All diesel-powered equipment and plant vehicles should be kept at a high level of maintenance. This should particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment should serve as trigger for withdrawing it for maintenance.
- For new equipment to be installed as part of the upgrade and expansion, equipment with lower sound power levels must be selected. Vendors should be required to guarantee optimised equipment design noise levels.
- In managing noise specifically related to truck and vehicle traffic, efforts **should** be directed at:
 - Minimizing individual vehicle engine, transmission, and body noise/vibration. This is achieved through the implementation of an equipment maintenance program.
 - Maintain road surface regularly to avoid corrugations, potholes etc.
 - Avoid unnecessary idling times.
 - Minimizing the need for trucks/equipment to reverse. This will reduce the frequency at which disturbing but necessary reverse warnings will occur. Alternatives to the traditional reverse 'beeper' alarm such as a 'self-adjusting' or 'smart' alarm could be considered. These alarms include a mechanism to detect the local noise level and automatically adjust the output of the alarm is so that it is 5 to 10 dB above the noise level near the moving equipment.
- Where possible, noisy activities such as construction, decommissioning, start-up and maintenance, should be limited to day-time hours.
- In the event that noise related complaints are received short term (24-hour) ambient noise measurements should be conducted as part of investigating the complaints. The results of the measurements should be used to inform any follow up interventions.

Emergency situations

None identified.

7.6 SOCIO-ECONOMIC

The information in this section was sourced from the social and economic specialist studies in Appendices H1 and H2 (Van Zyl, 2016 and Barbour, 2017).

7.6.1 INTRODUCTION

In the broadest sense the activities associated with the proposed project will have socio-economic impacts in all phases. Some of these are considered to be positive impacts and others are considered to be negative impacts. The separate groups of impacts are discussed below and must be read in the context of the baseline information included in Section 4.

7.6.2 ISSUE: IMPACTS ASSOCIATED WITH PROJECT EXPENDITURE: CONSTRUCTION PHASE

The construction phase of the project would result in spending injections that would lead to increased economic activity. This aspect is best measured in terms of impacts on employment and associated incomes focusing on the local area and region.

All expenditures will lead to linked direct, indirect and induced impacts on employment and incomes. In the case of employment, impacts would be direct where people are employed directly for the construction of new project components (e.g. jobs such as construction workers). Indirect impacts would be where the direct expenditure associated with the project leads to jobs and incomes in other sectors (e.g. purchasing building materials maintains jobs in that sector) and induced impacts where jobs are created due to the expenditure of employees and other consumers that gained from the project. Ordinarily, direct impacts are the most important of these three categories as they are the largest and more likely to be felt in the local area. They can also be estimated with the highest degree of certainty. The quantification of indirect and induced impacts is a less certain exercise due to uncertainty surrounding accurate multipliers.

Construction expenditure would constitute a positive injection of new investment. Preliminary estimates indicate that a total of around N\$722 million would be spent on all aspects of construction over the roughly one and half year construction period (see Table 7-6)

TABLE 7-6: CONSTRUCTION PHASE EXPENDITURE

Construction and establishment component	Expenditure (2016 N\$ million)	% of total costs that would go to suppliers in the local municipal area (ie Tsumeb)	% of total costs that would go to suppliers in the rest of Oshikoto	% of total costs that would go to suppliers in the rest of Namibia	% of total costs that would be direct imports
Civils, structural	85	37%	9%	54%	0%
Machinery and equipment	314	10%	3%	8%	78%
Electrical and instrumentation	69	16%	5%	42%	37%
Indirects	254	32%	1%	10%	57%
Total	722				

The project would have a positive impact on commercial activity particularly in the local area and region during construction given its size and the expenditure associated with it outlined above. During the construction phase the building construction, civil and other construction and specialist industrial machinery sectors would benefit substantially. The structural metal products, wholesale and retail trade and construction materials sectors would also stand to gain due to indirect linkages.

A tentative indication of what percentage of construction expenditure would go to suppliers from Tsumeb, the rest of Oshikoto, the rest of the country and what would be imported is provided in Table 7-6. Imports would primarily comprise specialised machinery and equipment not available in Namibia. Table 7-7 sets out the likely construction spend per geographic area using the overall amounts and percentages in Table 7-6. It is expected that about N\$155.8 million should be spent in the local area. A further N\$26.2 million is expected to be spent in the other parts of Oshikoto; N\$127.4 million in the remaining parts of Namibia and a further N\$413.5 million is projected to be spent on imports.

TABLE 7-7: CONSTRUCTION PHASE EXPENDITURE PER GEOGRAPHIC AREA

Expenditure category	Spend on suppliers in the local municipal area (ie Tsumeb) (N\$ million)	Spend on suppliers in the rest of Oshikoto (N\$ million)	Spend on suppliers in the rest of Namibia (N\$ million)	Spend on direct imports (N\$ million)
Civils, structural	31.6	7.9	45.5	-
Machinery and equipment	32.8	10.9	26.2	244.1
Electrical and instrumentation	10.9	3.6	29.2	25.2
Indirects	80.6	3.8	26.5	144.1
Total	155.8	26.2	127.4	413.5

Employment and incomes during construction

As set out in Section 5.4.9, it is estimated that a total of 185 person-years of direct temporary employment would be generated during the one and a half year construction period.

Another way to quantify the positive impacts resulting from construction phase employment is to consider the salaries which would be paid to employees. Table 7-8 shows the estimate that just over N\$53 million would be paid as salaries during construction based on likely salary averages. The divisions between the various skill levels are also shown.

TABLE 7-8 TOTAL SALARIES AND WAGES ASSOCIATED WITH THE CONSTRUCTION PHASE OF THE PROJECT (N\$)

Low skill	Medium skill	High skill	Total
2 782 000	24 815 000	25 543 000	53 140 000

In addition to the above direct employment and associated income opportunities, a significant number of temporary indirect and induced opportunities would be associated with the project. These would stem primarily from expenditure by the applicant in the local area and region as well as expenditure by workers hired for the construction phase.

7.6.2.1 Assessment of impact

Severity

The construction phase of the project would create a number of temporary direct and indirect employment opportunities and related expenditure within the local, regional and national economy.

Based on the above analysis, the severity of the potential impact is considered low positive in both the unmitigated and mitigated scenarios.

Duration

The duration of these positive impacts is considered low as it would be limited to the construction period of between one and a half and two years.

Spatial scale

Impacts would primarily be experienced at the local to national scale, although the local spend on construction will generate the most significant economic benefits for the town of Tsumeb. The spatial scale is considered medium.

Consequence

Based on the above assessment, the consequence of the positive economic impacts during the construction phase is low.

Probability

The probability of these impacts occurring is medium for the unmitigated and high for the mitigated scenario.

Significance

The overall significance is rated as low to medium for both the unmitigated and mitigated scenarios. SLR's confidence level is high for this significance rating.

Tabulated summary of the assessed impact – project expenditure: construction

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	L+	L	M	L+	H	L-M+
Mitigated	L+	L	M	L+	H	L-M+

7.6.2.2 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the Consolidated EMP in Appendix K.

Objective

To maximise benefits to the local and previously disadvantaged population.

Actions to enhance the positive impacts

- Set targets for how much local labour should be used.
- Maximize opportunities for the training of unskilled and skilled workers from local communities.
- Utilise local sub-contractors where possible.
- Ensure that contractors that tender for work from outside the local area meet targets for how many local employees are appointed.
- Explore ways to enhance local community benefits with a focus on well-conceived projects that are clearly aligned with local needs and acceptable to the municipality.
- In consultation with the Tsumeb Municipality, develop a database of local companies, specifically Small Medium and Micro Enterprises (SMME's), that qualify as potential service providers (e.g. construction, catering, waste collection and security companies). Notify these companies of tender processes for contracts at the smelter.

Additional enhancement measures are detailed in the Consolidated EMP in Appendix K.

Emergency situations

None identified.

7.6.3 ISSUE: IMPACTS ASSOCIATED WITH PROJECT EXPENDITURE: OPERATIONAL PHASE

Similar to the construction phase of the project, the operational phase would result in spending injections that would lead to increased economic activity.

Indirect economic impacts are an important aspect of the proposed project's overall impact, as it will have limited direct impacts during the operational phase. Indirect impacts were thus assessed in detail, focusing on first round indirect impacts based on primary data from suppliers and thereby avoiding multiplier analysis and its associated uncertainties. Other unquantified indirect and induced impacts were also borne in mind by the economic specialist.

The expansion will basically entail a substantial increase in the plant's capacity to treat copper concentrate, leading to an increase in production as outlined in Section 5. The key operational phase impacts associated with the project would flow from increased expenditure on operations at the plant following the expansion. Once the full expanded production has been reached (370,000 tpa), total operational expenditure associated with the plant should be approximately N\$1.577 billion per annum in 2016 terms, up approximately N\$288 million from the N\$1.289 billion budgeted for 2017.

Aside from the amounts involved, the nature of this expenditure will play a key role in determining impacts. For example, while there would be increased expenditure on key suppliers, the expansion would not require the hiring of new staff. In the following sections, current levels of employment and supplier expenditure at the plant are outlined in order to provide context after which the impacts of the expansion are assessed with a focus on first round indirect employment impacts.

The expansion will not require that additional staff be hired at the plant. There is an exception in the case of contractors, in that two additional staff will be required for refractory and mechanical maintenance. Additional direct employment due to the expansion would be limited to these two contractors.

The bulk of additional employment resulting from the expansion would result from indirect job opportunities. These would stem primarily from increased expenditure by DPMT in the local area and region, predominantly on the following items described in more detail below:

- Electricity
- Transport and handling services
- Engineering services
- Local municipal services

Electricity is currently supplied directly to DPMT by NamPower and would need to increase for the expansion. Due to the economies of scale associated with electricity provision, increased employment would be minimal despite the substantial increase in expenditure on electricity

DPMT relies on companies such as Grindrod for handling and storage of concentrate at the Walvis Bay port bulk terminal. The company employs 26 staff and it was determined that Grindrod currently relies on DPMT for a substantial portion of its turnover. It will be a key beneficiary from the expansion due to increased volumes through the part of the port which it manages.

Engineering and maintenance services are primarily provided to DPMT by a few companies located in Tsumeb and Windhoek. Quant is, for example, a significant supplier of such services and it employs a total of 181 employees. It was estimated that over half of Quant's turnover comes from DPMT. It is also likely that Quant and other engineering and maintenance suppliers will receive moderately larger amounts of work from DPMT if the expansion goes ahead.

DPMT relies on the municipality primarily for the provision of potable water. The municipality currently generates about N\$2.7 million per year from water sales to DPMT, and this will likely increase by about 20% with the finalization of the expansion. As with electricity, this would provide financial benefits, but is unlikely to result in additional jobs due to economies of scale.

In order to get an adequate indication of additional indirect employment at DPMT's suppliers as a result of the expenditure increases outlined above, DPMT's supplier database was used to obtain expenditure on suppliers, categorised according to the degree to which they rely on DPMT for their business turnover. Data were also obtained on the number of employees working at these suppliers. A roughly direct relationship between turnover and employment was then assumed in order to estimate the number of jobs at all local suppliers reliant on DPMT business. For example, if a supplier has 20 employees, and that supplier is reliant on DPMT for 50% of their turnover, then DPMT was assumed to support roughly 10 jobs. Each supplier was then analysed to determine the extent to which they would experience increased demand resulting from the expansion. The results are presented in Table 7-9. The table shows that DPMT currently indirectly supports between 337 and 510 jobs at its suppliers. Between 16 and 32 first round indirect jobs are likely to be generated by the expansion, of which between 7 and 14 jobs are likely to be created in Tsumeb, with the remainder split between Walvis Bay and Windhoek.

TABLE 7-9 INDIRECT FIRST ROUND EMPLOYMENT DURING THE OPERATIONAL PHASE

	Current	After upgrade	Additional
Indirect jobs supported in Tsumeb	86 - 138	93 - 152	7 - 14
Indirect jobs supported in Walvis Bay	28 - 42	32 - 49	4 - 7
Indirect jobs supported in the rest of Namibia	220 - 322	224 - 333	5 - 11
Indirect jobs supported in other countries	3 - 8	3 - 8	0 - 0
Total	337 - 510	353 - 542	16 - 32

The income associated with the above indirect first round jobs can be estimated by considering a likely average income for each of the additional employees. Assuming that the average additional employee earns N\$250 000 per annum, we can estimate that the total additional income associated with the above jobs in Namibia is between N\$4 million and N\$8 million. For Tsumeb the additional income was estimated to be between N\$1.7 million and N\$3.5 million.

Note that the estimates above take into consideration the 'first round' of expenditure on DPMT's suppliers thereby capturing a significant portion of total eventual impacts which would include indirect and induced impacts from subsequent rounds of spending (i.e. supplier that benefit from first round expenditure would, in turn, spend on their suppliers and so on). Impacts from subsequent rounds of spending were not quantified, but their likely magnitude was taken into consideration when impact significance ratings were determined.

7.6.3.1 Assessment of impact

Severity

Based on the above, the severity of the positive impact associated with increased expenditure during the operational phase will be low without mitigation and low-medium with mitigation

Duration

The duration would be for the life of the project and is thus considered as medium term.

Spatial scale

Impacts would be experienced on the local to national scale, although the local spend on operations will generate the most significant economic benefits for the town of Tsumeb. The rating is considered high with and without mitigation.

Consequence

Based on the above assessment, the determining positive consequence is low in the unmitigated scenario and medium in the mitigated scenario.

Probability

The probability of this impact occurring is high.

Significance

Summarising the above assessment, the overall significance is rated as low to medium positive in the unmitigated scenario and medium positive in the mitigated scenario. This assessment is based only on additional opportunities to be created.

Tabulated summary of the assessed positive impact – operational phase expenditure

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	L+	M	H	L+	H	L-M+
Mitigated	L-M+	M	H	M+	H	M+

When assessed as cumulative to current operational expenditure, the significance rating is increased to high positive.

7.6.3.2 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the Consolidated EMP (Appendix K).

Objective

To maximise benefits to local and previously disadvantaged populations.

Actions

Actions are similar to those recommended for the construction phase in Section 7.6.2 and in the Consolidated EMP in Appendix K.

Emergency situations

None identified.

7.6.4 ISSUE: INCREASED CORPORATE SOCIAL RESPONSIBILITY EXPENDITURE

Being the largest company in Tsumeb, DPMT is well positioned to support the surrounding community through its corporate social responsibility (CSR) programmes. DPMT's CSR budget for 2016 was approximately N\$12 million. Of this, N\$7 million was allocated to spending on housing for company employees, while the remaining N\$5 million was earmarked for spending on the Tsumeb Community Trust (N\$3.75 million) and on other donations (N\$1.24 million). Spending allocations within the Tsumeb Community Trust between 2010 and 2015 are set out in Table 7-10. Further details regarding the different spending allocations are provided in Appendix H.

7.6.4.1 Assessment of impact**Severity**

In line with the increases in operational expenditure which will accompany the proposed expanded operations, there will also be changes in revenue and foreign exchange flows. On the basis of recently increased budget allocations to the Tsumeb Community Trust, the expectation is that there will also be an increase in the quantity of revenues which are directed to CSR spending. It is, however, difficult to ascertain the magnitude of this increase and how proportional it will be to increased revenue or profit.

Improvements in social wellbeing from CSR investment are predicted to increase in line with increased revenue generated by the plant. The severity is considered low to medium in both the unmitigated and mitigated cases.

TABLE 7-10 SPENDING ALLOCATIONS WITHIN THE TSUMEB COMMUNITY TRUST, 2010 - 2015

	Current target allocation of spending	Total spent between 2010 and 2015 (N\$)	Actual allocation of spending
Education	40%	4,470,000	44%
SME Development	30%	2,428,000	24%
Social Welfare	15%	1,497,000	15%
Environment	7.5%	639,000	6%
Arts, Culture	7.5%	347,000	3%
Other		427,000	4%
Administration costs		332,000	3%
Total	100%	10,140,000	100%

Duration

The duration would be for the life of the project and is thus considered of medium term.

Spatial scale

The CSR investments target the local area specifically. The spatial scale is thus rated as low to medium.

Consequence

The consequence of these positive impacts is low to medium in both the unmitigated and mitigated cases.

Probability

The probability that CSR spending will increase in line with the increased revenue generated by the project is considered medium in both the unmitigated and mitigated cases.

Significance

Summarising the above assessment, the significance of these positive impacts is rated as low to medium without mitigation and medium with mitigation.

Tabulated summary of the assessed positive impact of increased CSR spending

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	L-M+	M	L-M	L-M+	M	L-M+
Mitigated	M+	M	L-M	M+	M	M+

When assessed as cumulative to current CSR contributions, the significance rating is increased to high positive given the already significant contributions being made.

7.6.4.2 Conceptual description of mitigation measures

Objective

To maximise CSR spending in order to benefit the local and regional economy.

Actions

As the programmes invested in already aim to maximise DPMT's contribution to the welfare of the local population, no specific enhancement measures are proposed. It is, however, suggested that the option of developing the Tsumeb Sports Club into a youth resource centre be investigated.

Emergency situations

None identified.

7.6.5 ISSUE: MACRO-ECONOMIC BENEFITS

The scale of the proposed expansion and its export orientation should ensure that it makes a significant contribution in terms of macro-economic benefits

7.6.5.1 Assessment of impact

Severity

The key variable chosen for the measurement of these benefits is foreign exchange earnings bearing in mind that DPMT does not pay corporate tax due to its Export Processing Zone status.

Current and likely post-expansion foreign exchange earnings were calculated as shown in Table 7-11, based on information provided by DPMT. Foreign exchange earnings resulting from the expansion would average around US\$66 million per year for copper blister and sulphuric acid exports. These would be in addition to current earnings of approximately US\$140 million per year. Further details regarding the calculations of potential macro-economic benefits are provided in Appendix H.

Foreign exchange earnings are likely to have a strong positive impact on the economy. The severity of this impact is thus considered medium to high for both the unmitigated and mitigated cases.

Duration

The duration would be for the life of the project and is thus considered of medium term.

Spatial scale

Foreign exchange earnings will be used to fund operational expenditure and CSR investments and improve the country's balance of payments, which will have both local and national impacts. The spatial scale is thus rated as high.

TABLE 7-11: THE RELATIONSHIP BETWEEN INPUTS, OUTPUTS AND FOREIGN EXCHANGE EARNINGS

	Current	Once expansion complete		Additional due to expansion once fully operational
		1st year after construction (2019)	2nd year onwards (2020)	
Inputs				
Imports of concentrate (tpa)	240,000	300,000	370,000	130,000
Outputs/production				
Copper blister				
Export volumes (tpa)	60,000	75,000	92,500	32,500
Net forex revenue (US\$)	126,829,000	155,536,000	182,625,000	55,796,000
Sulphuric acid				
% of sulphur dioxide than can be sold	100%	100%	100%	
Export volumes (tpa)	182,000	257,000	323,000	141,000
Revenue from exports (US\$)	13,650,000	19,275,000	24,225,000	10,575,000
Namibian sales volumes (tpa)	40,000	40,000	40,000	
Revenue from local sales	4,211,000	4,211,000	4,211,000	

Consequence

Based on the above assessment, the determining consequence is medium to high positive in both the unmitigated and mitigated cases.

Probability

The probability of the occurrence is high.

Significance

Given the levels of foreign exchange which would be generated as a result of the proposed expansion, but also considering the potential for some outflows, the significance of this positive impact is rated as medium to high.

Tabulated summary of the assessed positive impact related to macro-economic benefits

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	M-H+	M	H	M-H+	H	M-H+
Mitigated	M-H+	M	H	M-H+	H	M-H+

When assessed as cumulative to the significant foreign exchange earnings associated with existing DPMT operations, the significance rating is increased to high positive.

7.6.5.2 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the Consolidated EMP (Appendix K).

Objective

Ensure that Namibian suppliers of goods and services are favoured by DPMT where possible.

Actions

DPMT are to purchase from Namibian suppliers where possible.

Emergency situations

None identified.

7.6.6 ISSUE: IMPACT OF CONSTRUCTION WORKERS ON LOCAL COMMUNITIES

The presence of construction workers from outside of the area associated with large construction projects can impact on local communities, specifically for projects located in rural areas or small towns. While the presence of construction workers does not in itself constitute a social impact, the manner in which construction workers conduct themselves can impact on the local community. In this regard the most significant negative impact is associated with the disruption of existing family structures and social networks. This risk is linked to the potential behaviour of male construction workers, including:

- An increase in alcohol and drug use;
- An increase in crime levels;
- An increase in teenage and unwanted pregnancies;
- An increase in prostitution; and
- An increase in sexually transmitted diseases (STDs).

7.6.6.1 Assessment of impact

Severity

As stated in Section 4.10.2, there has been a rapid increase in the population of Tsumeb in the last five years with a significant influx of people into the town. In addition, Tsumeb is the gateway to northern Namibia and Angola and large numbers of truck drivers and other road users pass through the town on a monthly basis. The presence of additional workers from outside the area over a period of 18-24 months

is therefore unlikely to have a significant impact on the local community. The potential risk posed by construction workers from outside the area is therefore likely to be low.

While these impacts will be low at a community level, at an individual and family level they may be more significant, especially in the case of contracting an STD or an unplanned pregnancy.

Taking the above into consideration, the severity in both the unmitigated and mitigated scenarios is rated as low.

Duration

The duration of impacts would be limited to the construction phase and is thus considered as short term, resulting in a low rating.

Spatial scale

The spatial scale is medium as the impacts are local but beyond the site boundary.

Consequence

The consequence in both the unmitigated and mitigated scenarios is considered low.

Probability

The impact will be possible without mitigation and unlikely with mitigation, resulting in a medium rating for the unmitigated scenario and low rating for the mitigated scenario.

Significance

Summarising the above assessment and considering the higher severity of the impact to individuals in the unmitigated scenario, the significance of this potential impact is rated as medium without mitigation, reducing to low with mitigation.

Tabulated summary of the assessed impacts of construction workers on local communities

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	L	L	M	L	M	M
Mitigated	L	L	M	L	L	L

7.6.6.2 Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the Consolidated EMP (Appendix K).

Objectives

To minimise the impact of construction workers on the local communities.

Actions

Some of the specific actions include the following:

- Where possible, DPMT should make it a requirement for contractors to implement a 'locals first' policy for construction jobs, specifically for semi and low-skilled job categories;
- Consider the establishment of a Monitoring Forum (MF) in order to monitor the construction phase and the implementation of the recommended mitigation measures. The MF should be established before the construction phase commences, and should include key stakeholders, including representatives from local communities, local councillors, and the contractor(s). The MF should also be briefed on the potential risks to the local community associated with construction workers;
- DPMT and the appointed contractor(s) should implement an HIV/AIDS awareness programme for all construction workers at the outset of the construction phase;
- The contractors should make the necessary arrangements for allowing workers from outside the area to return home over weekends and/ or on a regular basis. This would reduce the risk posed to local family structures and social networks. DPMT should investigate how to contractually compel contractors to make the necessary arrangements; and
- The contractor must ensure that all construction workers from outside the area are transported back to their home towns within a day of their contracts ending. This will reduce the risk of construction workers remaining in the area once their contracts come to an end.

Additional measures are detailed in the Consolidated EMP in Appendix K.

Emergency situations

Stakeholders are best handled through a transparent Public Consultation and Disclosure Plan which is regularly reviewed to ensure stakeholders' concerns and grievances are addressed promptly.

7.6.7 ISSUE: SMELTER DECOMMISSIONING AND CLOSURE**7.6.7.1 Assessment of impact**

Given the relatively high number of permanent employees (667) the potential impacts associated with potential future decommissioning and closure of the smelter would be significant. The major social impacts associated with the decommissioning phase are linked to the loss of jobs and associated income. This has implications for the households who are directly affected, the communities within which they live, and the relevant local authorities.

The impacts for the households who are directly affected by the retrenchment and loss of income associated with decommissioning include the inability to pay bills (such as household bonds, lights, water and property rates, buy food, pay school fees, etc.). Despite every effort to manage the decommissioning process, some employees who lose their jobs may feel that they let their families down. The resultant loss of self-esteem can cause depression, etc. Retrenchments can therefore have a significant impact on the directly affected households.

The impact on communities in which the people live can also be severely impacted upon by loss of jobs associated with decommissioning. The impacts may include increase in crime, alcohol and drug abuse, decreased economic activity, etc. Likewise, local authorities can also be severely affected by the loss of jobs associated with decommissioning. The impacts are linked to the inability of residents to pay bills, increased crime, alcohol and drug abuse, etc. All of these issues impact on the ability of the local authorities to provide a living environment that is conducive to the community's well-being.

In the absence of an effective plan to manage the social and economic impacts associated with smelter closure and decommissioning the impacts will be significant. However, the potential impacts associated with the decommissioning phase can be effectively managed with the implementation of an effective and well planned retrenchment and downscaling programme. The current proposed project would extend the viability of the smelter and thus defer the ultimate negative impacts related to decommissioning and closure.

The severity of potential negative social impacts associated with a loss of employment due to decommissioning is rated as medium without mitigation and low with mitigation, assuming effective planning.

Duration

The duration of these negative impacts is considered to be low as it is deemed to be reversible.

Spatial scale

The spatial scale is considered as local to regional, as it is also likely to affect current service providers in the Port of Walvis Bay.

Consequence

The consequence of closure-induced negative economic impacts is considered low without and with mitigation.

Probability

The probability of these impacts occurring is high without mitigation, but low with mitigation.

Significance

Summarising the above assessment, the significance of the impacts is rated as medium without mitigation and low with mitigation.

Tabulated summary of the assessed socio-economic impacts due to decommissioning and closure

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	M	M	M	M	H	M
Mitigated	L	L	L	L	L	L

7.6.7.2 Conceptual description of mitigation measures

Objectives

The mitigation objective is to minimise the impacts associated with job losses during decommissioning.

Actions

- Ensure that retrenchment packages are provided for all staff who stand to lose their jobs when the smelter is closed;
- Implement a skills training programme to equip employees with skills they can use when the smelter closes. The skills development programme should be designed to take into account current education and skills levels of employees. The skills training programme should be implemented from the outset of the operational phase and should be funded by DPMT;
- Provide employees with a basic financial management course to enable them to make informed decisions with regard to investing their earnings; and
- DPMT should ensure annually that its Asset Retirement Obligations are accurate and current in order to fund the Closure Plan objectives.

Emergency situations

Should at any point it seem likely that the smelter may have to cease operations early and / or go into care and maintenance, employees, suppliers and all other key stakeholders should be informed promptly and given enough time to make financial adjustments.

7.7 COMMUNITY HEALTH

The information in this section was sourced from the community health assessment in Appendix I (Myers, 2016). This section should be read with the air quality impact assessment findings (Section 7.4 and Appendix F). The potential impacts were considered as cumulative with the community health impacts being experienced, taking the current smelter operations as well as the proposed expansion into consideration.

7.7.1 ISSUE: COMMUNITY HEALTH IMPACTS RELATED TO SO₂ AND PM₁₀ EXPOSURE

7.7.1.1 Assessment of impact

Taking into account the current health hazards, baseline community health status and exposure pathways as described in Section 4.15, no qualitatively new hazards are likely to be introduced as a result of the proposed increased production throughput at the smelter.

Severity

SO₂

Although a marked decrease in SO₂ emissions has been experienced after the installation of the sulphuric acid plant and other capital improvements at the smelter, exceedance of the SA NAAQS and WHO 24-hour limit was still recorded on a monthly basis outside of the smelter boundary (see Table 7-1 for relevant standards). Exceedances of the SA NAAQS standards (125 µg/m³) were recorded at the monitoring stations closest to the smelter (i.e. Plant Hill and Sewage Works), but not at the monitoring stations within Tsumeb (i.e. Info Centre and Sport Stadium). As DPM is an international company, the community health specialist also considered the stricter WHO standard (20 µg/m³) applicable to first world countries in his assessment. Significance ratings were, however, still comparable with the air quality assessment ratings for which the SA NAAQS and interim WHO standard (125 µg/m³) was used. Linn *et al.* (1987) found that there was no irreversible adverse respiratory impact as measured by lung function on asthmatics and atopic individuals under conditions of exposure at least an order of magnitude higher than levels experienced in the Tsumeb area. These findings were also confirmed by the results of the respiratory health questionnaires completed by Tsumeb residents. The SO₂ exceedances, however, have an irritant effect on the respiratory system, causing a symptom burden for the receptor population, especially for those with asthma-related symptoms. While the level of exposure is not likely to cause a substantial symptom burden or irreversible effects, there is definitely a nuisance burden experienced by Tsumeb residents.

It was noted in the specialist assessment that capital improvements were not yet fully implemented during 2016 when the study was undertaken and that it can be assumed that when these improvements function optimally, they would result in further reduction in SO₂ exposures going forward. Improved ventilation extraction from new convertors and new methods of slag cooling may be expected to bring about further future reductions in exposure. With the sulphuric acid plant functioning at its optimal design capacity, the appropriate use of hoods at the RHF and improved ventilation extraction, increasingly more efficient capture of SO₂ would be likely, notwithstanding any increase in the production throughput.

PM₁₀

As set out in Section 4.15, the current burden of disease caused by PM₁₀ for Tsumeb residents is considered to be small (estimated as 2.5 days of life lost per individual). Simulation results of the air quality assessment showed that it is not expected that increased PM₁₀ emissions as a result of the expanded smelter operations would cause an exceedance of daily PM₁₀ WHO interim targets (i.e.

75 µg/m³) or stricter WHO first world targets (i.e. 50 µg/m³) outside of the smelter footprint. It is thus not expected that the proposed project would add cumulatively to the current burden of disease experienced from PM₁₀ sources.

Based on the above, the severity of the impact largely relates to the upper and lower respiratory symptoms attributable to SO₂ exposures experienced in all areas of Tsumeb. The impact is assessed as cumulative to the current effects experienced by Tsumeb residents. The severity is rated as medium for both the unmitigated and mitigated scenarios.

Duration

Impacts of SO₂ exposure are considered to be irritative in nature and are thus short-lived and reversible over time. Duration is thus rated as low.

Spatial scale

Although the exposures are local to the Tsumeb area, it is considered relatively widespread beyond the smelter boundary and thus rated as medium without and with mitigation.

Consequence

Based on the above, the consequence is considered medium without mitigation and with mitigation.

Probability

The probability of these impacts occurring is high without mitigation, but low with mitigation.

Significance

Summarising the above assessment, the significance of the impacts is rated as medium without mitigation and low with mitigation.

Tabulated summary of the community health impacts from SO₂ and PM₁₀ exposure

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	M	L	M	M	H	M
Mitigated	M	L	M	M	L	L

7.7.1.2 Conceptual description of mitigation measures

Objectives

The mitigation objective is to reduce the Tsumeb community's exposure to SO₂ from the smelter operations in order to comply with the relevant air quality standards and limit irritation from SO₂ inhalation.

Actions

- Implement engineering solutions to better control fugitive emissions at all components of the smelter operations, particularly capturing emissions at the converters and from slow cooling of slag.
- Ensure monitoring stations are all functional for SO₂ and PM₁₀.
- Adapt the air quality monitoring stations to additionally test for the PM_{2.5} parameter (already completed).

Also refer to air quality mitigation measures in Section 7.4 and the Consolidated EMP in Appendix K.

Emergency situations

None identified.

7.7.2 ISSUE: HEALTH IMPACTS OF ARSENIC EXPOSURES TO TSUMEB COMMUNITIES

Similar to SO₂ exposures, no qualitatively new arsenic exposure pathways are likely to be introduced as a result of the proposed increased production throughput at the smelter.

When considering the latest emissions data together with results of the urine arsenic levels, elevated urine arsenic levels were found in Tsumeb when compared to unexposed control samples in Oshakati. The main findings of the community health investigation, however, showed that there did not seem to be a general systemic overexposure problem based on urine inorganic arsenic for Tsumeb residents as a whole. The geometric mean was actually found to be well below the most conservative international occupational hygiene standard of 35 µg/l (American Conference for Governmental Industrial Hygienists - ACGIH). The overall impacts on Tsumeb communities were thus estimated to be negligible.

Further detailed investigations were recommended for Ondundu in Town North, where mean arsenic levels were significantly higher, and where there was a high proportion (18.9%) of outliers above the Namibian Biological Exposure Index for inorganic arsenic of 50 µg/g. As the results of the investigation showed that arsenic in PM₁₀ and in drinking water could not be responsible for the elevated urine arsenic levels in outlier samples from Ondundu, attention must be directed to arsenic in dust from roadways and garden soil, arsenic in vegetables and fruit grown locally in Ondundu, and hand to mouth behaviour by both children and adults resulting in arsenic ingestion.

The risk of additional lung cancer above baseline expectation due to environmental arsenic exposure is negligible for Tsumeb overall. This includes Tsumeb suburbs, with the exception of the Ondundu in Town North where the risk is considered to be low (further details regarding the calculations of cancer risk factors are provided in Section 13.2 of the community health assessment in Appendix I).

When considering the proposed increased throughput capacity, regression analysis of the throughput data and latest monitoring results of the Plant Hill monitoring station (immediately south of the hazardous waste disposal site) near Ondundu was undertaken. The results showed that there is no relationship between quantities of total concentrate processed at the smelter monthly and air quality, measured as arsenic in PM₁₀, at Plant Hill, or any of the other ambient air quality monitoring stations outside of the smelter complex. No significant increase in airborne arsenic exposures for residents might then be expected at the proposed increased throughput capacity. Alternative options for hazardous arsenic waste disposal are currently being investigated by DPMT, with investigations at an advanced stage. The closure and capping of the hazardous waste site once the approved capacity is reached would likely result in a further reduction in environmental arsenic exposures to both the smelter employees and Tsumeb residents, particularly the closest residential areas at Ondundu.

It was noted in the specialist assessment that capital improvements were not yet fully implemented during 2016 and that it can be assumed that when these improvements function optimally, it would result in further reductions of arsenic exposure going forward.

While the shutdown of the arsenic plant, one of the most antiquated components at the facility, at the end of February 2017 will result in a reduction in arsenic exposure for employees at the plant, it would also result in an increase in the volumes of arsenic waste to be disposed of at the hazardous waste disposal site. If not well managed, windblown arsenic-containing dust (albeit of a less concentrated form of arsenic) from the waste site could contribute to an increase in arsenic exposures which could potentially increase proportionately with an increase in the throughput capacity, as a worst case scenario. Appropriate dust suppression measures are thus critical for arsenic containment.

Given the presumptive predominance of the air exposure pathway in determining the impact of the soil exposure pathway on absorbed arsenic as measured in urine arsenic, the latter should decline with the closure of the arsenic plant and especially with further engineering improvements for the management of fugitive dust emissions at the smelter.

Severity

For the community overall, the risk of lung cancer from arsenic exposure for both the unmitigated and mitigated scenarios is considered low. As the Ondundu area is a more highly exposed outlier, the overall risks of developing lung cancer from arsenic exposures are considered to be higher for this area. For Ondundu, the risk is considered medium for the unmitigated scenario and low for the mitigated scenario.

As the impact relates to the potential development of cancer, the severity of the arsenic-related impacts and increased cancer risk from the current operations and the proposed smelter expansion is considered as high.

Duration

The duration is rated as high for both the unmitigated and mitigated scenarios due to the impact of arsenic exposure potentially causing cancer.

Spatial scale

The assessment indicated that exposure beyond the smelter boundary for Tsumeb as a whole is rated as low (Tsumeb town area) to medium (Ondundu area) for the unmitigated and low for the mitigated scenarios.

Consequence

Based on the above, the consequence is considered high in both the unmitigated and mitigated scenarios.

Probability

It is considered unlikely that lung cancer would be developed from current and future exposures with the proposed smelter expansion for the unmitigated scenario for the Tsumeb town area. The probability is rated as low (for the overall town area) to medium (Ondundu area) in the unmitigated scenario and low in the mitigated scenario.

Significance

Summarising the above assessment, the significance of the impact for Tsumeb as a whole is rated as low (overall town area) to medium (Ondundu area) in the unmitigated and low in the mitigated scenario.

Tabulated summary of the community health impacts from increased cancer risk due to arsenic exposure for Tsumeb as a whole

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	H	H	L-M	H	L-M	L-M
Mitigated	H	H	L	H	L	L

7.7.2.1 Conceptual description of mitigation measures

Objectives

The mitigation objective is to minimise the community's exposure to smelter inorganic arsenic as far as possible in order to comply with WHO limits.

Actions

- Closure of the arsenic plant (closed at the end of February 2017).
- Improved control of all fugitive emissions from the smelter.

- Future closure and covering of the hazardous waste disposal site after the permitted volume is utilised.
- Ensure that all devices at the ambient air monitoring stations are maintained in a functional state and rapidly repaired when necessary.
- Adapt the air quality monitoring stations to additionally test for the PM_{2.5} parameter (already completed).
- Undertake further investigations to determine arsenic levels in soil and vegetables/fruit and the effect of hand to mouth behaviours, along with further comparing Ondundu and control areas within and outside of Tsumeb. Should soil and home grown food arsenic levels be high, initial prohibition of growing home crops and removal of the topsoil layer should be considered. These additional investigations should inform further actions, which may include an exclusion zone being negotiated around the smelter.
- Further to the consideration of an exclusion zone, the Tsumeb Municipality would need to be consulted with regards to future landuse planning for the residential and farming areas closest to the smelter property. In this regard, proposed plans for a large vegetable garden in the Ondundu area and possible relocation of Soweto residents to Ondundu should be reconsidered until the levels of arsenic and other chemicals of concern (e.g. lead) and the related potential risks can be confirmed through further soil investigations.
- Undertake more urine arsenic sampling in the most affected and other undersampled areas within Tsumeb along with unexposed controls and set up a programme for ongoing periodic monitoring.

Also refer to air quality mitigation measures in Section 7.4 and the Consolidated EMP in Appendix K.

Emergency situations

None identified.

7.7.3 ISSUE: HEALTH IMPACTS OF ARSENIC EXPOSURES TO DPMT EMPLOYEES

The assessment of occupational health impacts do not as a rule form part of an ESIA process as occupational health is not dealt with in terms of environmental legislation. As concerns were, however, raised by unions and other I&APs during the scoping phase, occupational health concerns were also addressed as part of the community health assessment. This study component included a review of the use of personal protective equipment (PPE) by employees and assessed the likelihood of an increased cancer risk to employees from the proposed increased throughput capacity. Further details regarding the PPE review and occupational health hazards are provided in Section 2.6 of the community health assessment (see Appendix I). The likely impact on cancer risk to smelter employees is assessed below. This section is, however, only provided for information purposes, as the overall assessment focusses on third party impacts.

Severity

When assessing the relative risks for lung cancer, standards from the Agency for Toxic Substances and Disease Registry (ATSDR) as set out in Table 7-12 were considered.

TABLE 7-12: RELATIVE RISKS FOR LUNG CANCER (ATSDR)

Risk	Average arsenic air concentrations relative to risk increase
Low	0.05 – 0.30 mg/m ³ = 2 x the risk
Medium	0.30 – 0.60 mg/m ³ = 3 x the risk
High	1.5 – 3.0 mg/m ³ = 3.5 x the risk
Very High	5.0 mg/m ³ = 7 x the risk

Based on occupational hygiene exposure measurements, average airborne exposure levels are in the range of 0.01 to 0.60 mg/m³ for the different business units of the smelter precinct. Average levels in the different business units range from the lowest at 0.01 mg/m³ in the administration building to the highest at 0.6 mg/m³ in the arsenic plant. The corresponding cancer risks shown in Table 7-8 are multiples of the baseline (or no excess risk) and range between 1 x (no additional risk), through 2 x (low additional risk) and 3 x baseline (Medium risk) according to the ATSDR.

Biomonitoring of employees for urine arsenic content is undertaken regularly by DPMT. From the biomonitoring results at the smelter, for the plant as a whole the average total arsenic in urine was 74µg/g in 2016. For highly exposed groups the total arsenic in the urine is virtually all inorganic and thus toxicologically relevant and deemed to be related to smelter operations. Assuming this to be the case the urine arsenic levels can be calculated (using an ACGIH equation) as yielding a corresponding average air concentration of 0.25 mg/m³, and the associated risk according to the ATSDR is considered to be low (2 x baseline). Considering the above standards, and the fact that PPE and some engineering controls do not seem to be working, there is an appreciable occupational lung cancer risk on average for the plant as a whole; more in some business units than in others, depending upon the average air concentration in those units.

The corresponding risks as per Table 7-8 are mostly 2 to 3 times the expected background risk for lung cancer at these levels of exposure and thus deemed as a low to medium risk.

In order to assess the potential increase in arsenic exposures and related cancer risk for employees due to the proposed increased throughput capacity, a regression modelling exercise was undertaken using monthly quantities of total concentrate throughput going back to 2011, urine arsenic data from smelter employees going back to 2011, as well as air quality arsenic data from the five DPMT ambient air quality monitoring stations going back to 2012 (refer to Section 14.2 of the community health assessment for details on the methodology). Considering the results for the individual business units for 2016 data only, three showed slight increases in urinary arsenic linked to increased concentrate throughput. These were

the arsenic plant (which has since been closed), materials handling, and other (a small miscellaneous group of smelter employees roving about the smelter). For all the other business units the urine arsenic decreased slightly with increased throughput capacity. This result is likely due to the new capital improvements that have already been put in place and having an increasing effect in 2016 as a result of fixing teething problems with the new systems.

Consequently, regression modelling on the basis of the above results shows that, if continued improvement is maintained, there is little likelihood of increased exposure (increased urinary arsenic levels) going forward. There is an overall inverse relationship in which urine arsenic levels will decline slightly in the smelter with increased throughput. With the closure of the arsenic plant and as the capital improvements are completed in the near future and point of emissions are better controlled, urinary arsenic levels will decline further. Attention will, however, need to be directed particularly towards the materials handling business unit and to roving employees, and any other urinary arsenic spikes that are observed going forward.

As the principal health risk is arsenic-related cancer, the severity is deemed to be high without and with mitigation.

Duration

The duration is rated as high for both the unmitigated and mitigated scenario due to the impact of arsenic exposure potentially causing cancer.

Spatial scale

The spatial scale is considered to be local and thus rated as low for both the unmitigated mitigated scenarios.

Consequence

Based on the above, the consequence is considered high without mitigation and with mitigation.

Probability

The current baseline cancer risk is raised by twice the background risk for the smelter as a whole and three times for the arsenic plant (which has since been closed). Probability is thus rated as medium in the unmitigated scenario, but low in the mitigated scenario.

Significance

Summarising the above assessment, the significance of the impact is rated as high in the unmitigated scenario, but reduces to low to medium, assuming that mitigation measures are implemented successfully.

Tabulated summary of the occupational health impacts from increased cancer risk due to arsenic exposure

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	H	H	L	H	M	H
Mitigated	H	H	L	H	L	L-M

7.7.3.1 Conceptual description of mitigation measures**Objectives**

The mitigation objective is to reduce the workforce's exposure to smelter inorganic arsenic to within acceptable occupational exposure limits.

Actions

- Closure of the arsenic plant (closed at the end of February 2017).
- Improved control of fugitive emissions from slow cooling of slag, potentially enclosing cooling areas.
- Improved control of fugitive emissions at the converters by ensuring that hoods are in place with ventilation extraction when pouring.
- Strengthen the industrial hygiene programme with more emphasis on industrial hygiene led exposure control rather than biomonitoring.
- There should be more emphasis on reducing arsenic exposure pathways and less reliance on PPE.
- Continue to implement job rotations, but at lower arsenic cut-off values by the end of 2017.
- Improve safe work practices.

Also refer to air quality mitigation measures in Section 7.4 and the Consolidated EMP in Appendix K.

Emergency situations

None identified.

7.8 No-Go OPTION

Potential impacts relating to the no-go option of not implementing the proposed expansion project would largely relate to socio-economic aspects.

The no-go option would maintain the status quo in terms of operational expenditure, CSR investment and foreign exchange benefits, at best. At worst, the continued financial viability of the plant and the benefits associated with current operations may be put at risk. The proposed expansion is one of the later phases of an overall optimisation and expansion project which to date has required substantial investment. Recovering the costs of this investment would be significantly more challenging should the proposed expansion not go ahead.

When considering the current operational expenditure, CSR investment and foreign exchange benefits related to the Tsumeb smelter operations, the benefits are rated as of medium positive significance. Should the expansion not be fully realised, it is expected that the current socio-economic benefits would continue to be felt on a local, regional and national scale, with the significance of these benefits remaining at medium positive. The opportunity to increase the current significance of benefits to high positive would, however, not be realised.

With regards to other environmental impacts, the no-go option should not lead to any significant changes or increases from the status quo. This, however, assumes that a long term solution for the disposal of hazardous waste is implemented, that general waste and effluent management for current operations are addressed in line with recommendations made in the waste management review and that remediation of contaminated land is undertaken in line with closure objectives and DPMT's Biodiversity Action Plan.

8 KEY ASSUMPTIONS, UNCERTAINTIES AND LIMITATIONS

Assumptions, uncertainties and limitations relating to each of the environmental aspects are presented in detail in the various specialist studies (Appendices D to I) and will not be repeated in this report. Some general assumptions are described below.

8.1 ENVIRONMENTAL ASSESSMENT LIMIT

The ESIA does not cover an assessment of the alternative solutions for hazardous waste disposal or the addition of a waste incinerator for general waste. These aspects are mentioned in the ESIA, but no final decisions have been made on the appropriate solutions. Once a decision is made in this regard, the impacts will be addressed in a separate EIA.

The assessment of occupational health impacts do not as a rule form part of an ESIA process as occupational health is not dealt with in terms of environmental legislation. As concerns were, however, raised by unions and other I&APs during the scoping phase, occupational health concerns were also addressed as part of the community health assessment. As the ESIA focusses on third party impacts, the assessment of the potential increase in cancer risk to employees within the smelter was only included for information purposes in the impact assessment section of this EIR. In assessing health risks to employees from the proposed expansion project, the SLR impact significance rating scale was used. It must, however, be noted that the SLR assessment methodology and significance rating scale have been developed for third party environmental impacts and do not normally apply to occupational health issues.

8.2 PREDICTIVE MODELS IN GENERAL

All predictive models are only as accurate as the input data provided to the modellers. If any of the input data is found to be inaccurate or is not applicable because of project design changes that occur over time, then the model predictions will be less accurate.

It must be noted that air emissions modelling largely focussed on the latest data from 2016 after substantial capital investments in 2015. These investments included, amongst others, the commissioning of the sulphuric acid plant and addition of new converters and hoods to manage SO₂ and other fugitive emissions. These improvements resulted in a significant reduction in pollutant emissions from the smelter operations, with early positive monitoring results recorded. Some teething problems were still experienced in 2016, with exceedances of air emission standards still recorded off-site. It would've been preferable to base modelling exercises on a longer monitoring time period with the new project components (i.e. sulphuric acid plant and converter hoods) functioning optimally. The current ESIA timeframe, however, did not allow for longer monitoring periods.

9 ENVIRONMENTAL IMPACT STATEMENT AND CONCLUSIONS

A tabulated summary of the potential impacts is presented in Table 9-1 below. As can be seen from the table below, the impacts associated with the project vary from high positive to high negative without mitigation.

It is possible to mitigate the potential negative impacts by committing to apply the findings of the assessment and related mitigation objectives and actions as presented in the EMP. One of the potential negative impacts will remain of medium negative residual significance even with mitigation. This negative impact relates to the impact of the smelter operations on groundwater quality on and beyond the site boundary. It is important to note that current groundwater quality impacts are related to historic impacts of mining and processing activities on the site prior to the establishment of DPMT's current smelter operations. It is not expected that the proposed expansion project would lead to any measurable cumulative contribution to current groundwater quality impacts. The residual medium cumulative impact rating can thus be ascribed to the baseline groundwater quality conditions and not to the proposed expansion project. It was, however, noted that the current groundwater model would need to be updated in order to provide a more accurate prediction of the likelihood of contaminated groundwater migrating beyond the smelter boundary and build on already recommended mitigation measures for further reducing the significance of impacts on groundwater quality in the vicinity of the smelter complex.

With regards to the potential benefits of the proposed expansion project, the positive cumulative impacts related to socio-economic aspects (i.e. direct construction and operational project expenditure, indirect business opportunities, CSR contributions and macro-economic benefits) were all rated as of high significance after mitigation.

It must be noted that there are currently significant contamination levels on the smelter property and surrounds due to historic mining and smelter operations and legacy waste stockpiles. Although it is acknowledged that the current DPMT smelter operations, since DPMT purchased the facility in 2010, have contributed to and continue to contribute to the overall contamination load, the majority of the measured contamination levels and related impacts (i.e. groundwater and to some extent community health) are attributable to historic operations. The ongoing Contaminated Land Assessment will aim to quantify the historic and current contributions.

Based on the findings of this ESIA, it is not expected that the proposed increased throughput capacity of the DPMT smelter would have a significant contribution to current negative operational impacts. With the implementation of the proposed mitigation measures and further optimising of the already implemented engineering solutions for the management of air emissions, it is expected that cumulative negative impacts related to smelter operations would be reduced to acceptably lower levels.

The following key aspects with regards to current and future operations are to be addressed as a matter of priority by DPMT:

- Ensure that the sulphuric acid plant and other recent engineering interventions (e.g. hoods) are operating at optimal design levels in order to control SO₂ and other fugitive dust emissions;
- Disposal of general waste by implementing one of the following options:
 - Establishment of a general landfill site within the smelter footprint;
 - Development of a small waste incinerator (would require an additional EIA process); or
 - Disposal at a formalized/licensed municipal landfill site (additional municipal application process would be required).
- A final solution for the disposal of hazardous waste well in advance of the onsite hazardous waste disposal site reaching its full design capacity. The following alternatives should be further considered and a final decision made as soon as reasonably possible:
 - Disposal to a potential future regional site in Namibia;
 - Transport of waste to a suitable hazardous waste site in South Africa;
 - Vitrification of flue dust which would render arsenic wastes non-hazardous and saleable; or
 - A combination of the above options.

SLR is of the opinion that the proposed expansion project may be approved, on the condition that the above key aspects are addressed by DPMT as a priority.

TABLE 9-1: SUMMARY OF POTENTIAL IMPACTS ASSOCIATED WITH THE PROPOSED PROJECT

Section	Potential impact	Significance of the impact (the ratings are negative unless otherwise specified)	
		Unmitigated	Mitigated
Surface water	Changes in surface water runoff	L	L
	Surface water pollution	M	L
Groundwater	Groundwater quantity	M	L
	Groundwater quality	H	M
Air quality	Cumulative air pollution impacts	M	L-M
Noise	Cumulative noise pollution impacts	L	L
Socio-economic impacts	Construction phase project expenditure, including employment and downstream business opportunities	L-M ⁺	L-M ⁺
	Employment phase project expenditure, mainly related to indirect employment opportunities	L-M ⁺	M ⁺ H ⁺ (cumulative)
	Increased Corporate Social Responsibility expenditure	L-M ⁺	M ⁺ H ⁺ (cumulative)
	Macro-economic benefits	M-H ⁺	M-H ⁺ H ⁺ (cumulative)
	Impact of construction workers on local communities	M	L
	Smelter decommissioning and closure	M	L

Section	Potential impact	Significance of the impact (the ratings are negative unless otherwise specified)	
		Unmitigated	Mitigated
Community health impacts	Community health impacts related to SO ₂ and PM ₁₀ exposure	M	L
	Community health impacts of arsenic exposures to Tsumeb communities	L-M	L
	Health impacts of arsenic exposures to DPMT employees	H	L

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Eloise Costandius
(Project Manager)

Werner Petrick
(Reviewer)

APPENDIX A: ENVIRONMENTAL CLEARANCE CERTIFICATE

APPENDIX B: CURRICULUM VITAE OF ESIA TEAM

APPENDIX C: PUBLIC PARTICIPATION DOCUMENTATION

- IAP Database

Scoping Phase

- IAP Notifications
- Meeting Presentations
- Meeting Minutes and Comments
- Scoping Phase Issues and Responses Report

EIA Phase

- IAP Notifications
- Feedback Meeting Presentations
- Meeting Minutes

APPENDIX D: WASTE MANAGEMENT REPORT

APPENDIX E: GROUNDWATER AND SURFACE WATER ASSESSMENT

APPENDIX F: AIR QUALITY ASSESSMENT

APPENDIX G: NOISE ASSESSMENT

APPENDIX H: SOCIO-ECONOMIC ASSESSMENTS

H1: ECONOMIC IMPACT ASSESSMENT

H2: SOCIAL IMPACT ASSESSMENT

APPENDIX I: COMMUNITY HEALTH ASSESSMENT

APPENDIX J: DETAILS REGARDING RELEVANT LAWS, POLICIES, STANDARDS

APPENDIX K: CONSOLIDATED ENVIRONMENTAL MANAGEMENT PLAN



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