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Tsumeb Smelter

DPMT Waste Management Review

Solid Waste

SLR Project No.: 7NA.04040.00009

Report No.: Doc. no.1

Revision No.1.1

January 2017

Dundee Precious Metals Tsumeb

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EXECUTIVE SUMMARY

1. Introduction

Dundee Precious Metals Tsumeb (DPMT) owns and operates the Tsumeb Smelter, located on the outskirts of Tsumeb in the Oshikoto Region of Namibia. The Tsumeb Smelter processes copper concentrates from around the world, particularly those with a high arsenic content. The smelter has an annualized capacity of 240,000 tpa. DPMT holds a number of Environmental Clearance Certificates (ECC) for the smelter operations in terms of the Environmental Management Act, 2007

DPMT is currently considering plans for an increase in processing capacity of the Tsumeb Smelter to 370 000 tpa. The proposed Upgrade and Optimisation project requires the amendment of some of the project components approved under the ECCs. SLR Environmental Consulting (Namibia) (Pty) Ltd (SLR) is appointed to undertake an Environmental Impact Assessment (EIA) process, including the compilation of a consolidated Environmental Management Plan for all operations (current and proposed) at the smelter.

SLR was also appointed to provide a high-level overview and opinion on current waste management strategies and operational procedures at the Tsumeb Smelter, including for both general and hazardous waste. The scope of work covered in this report includes:

- Assessment of general waste management strategies relative to national and international legislation and best practice.
- Assessment of general design and operation of the hazardous waste site.
- Assessment of current practice and impacts of managed and unmanaged wastes at the site.
- A review of laboratory waste management procedures.
- Review of recycling practices and potential impacts.
- Consideration of point and nonpoint impacts of exposed material stockpiles.
- Assessment the tailings facilities and their contribution to the overall waste load.
- Contribution to the EIA process with regards to waste related issues.

2. Review of Waste Management Strategies

Waste management at the Tsumeb Smelter is undertaken in terms of a Waste Management Procedure (currently under review) as well as various related policies and procedures. SLR reviewed the draft Waste Management Procedure and had a variety of comments on the document and the methods. These were:

Purpose:

The DPMT Waste Management Procedure should extend beyond the “disposing of waste” and rather reference the “management of waste in terms of the waste management hierarchy” or the “management of waste in terms of appropriate best practice”. International best practice with regards to waste

management also advocates the application of the principles such as 'Polluter pays principle', 'Proximity principle' and the 'Precautionary principle'.

Scope:

The scope of the Waste Management Procedure should be broadened to "all activities that generate waste or involve the management of waste at the Tsumeb Smelter". Consideration should be given excluding the management of mineralised wastes from the Procedure if the mineralised wastes are adequately managed through other procedures. It is further recommended that DPMT develop a Waste Register in which all wastes generated across all facilities and operations at the Tsumeb Smelter are documented.

Reference:

Waste management at the Tsumeb Smelter should aim to ensure compliance with relevant legislation. Articles 91(c) and 95 of the Namibian Constitution (Article 95) provide overarching guidance in terms of the maintenance and sustainable use of natural resources for the benefit of all Namibians, both present and future. The Environmental Management Act sets out principles of environmental management which includes that "the reduction, re-use and recycling of waste must be promoted". Article 5 of the Act provides that a person may not discard or dispose of waste, except (a) at a disposal site declared or approved by the Minister or (b) in a manner or by means of a facility or method and subject to such conditions as the Minister may prescribe. The 'construction of facilities for wastes sites, treatment of waste and disposal of waste' and 'the import, processing, use and recycling, temporary storage, transit or export of waste' may not be undertaken without an ECC. It is noted that Namibia is developing further legislation to regulate waste management and public health as reflected in the Pollution Control and Waste Management Bill (circa 2003) and the Public and Environmental Health Bill (2014). The DPMT Waste Management Procedure should give consideration to the intentions of these Bills in as much as this is feasible.

As Namibia is a signatory to a number of multilateral environmental agreements, which conventions form part of the law of Namibia, the DPMT Waste Management Procedure should give effect to the requirements of these agreements where possible. These include:

- The **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)**.
- The **Stockholm Convention on Persistent Organic Pollutants (2001)**.
- The **United Nations Framework Convention on Climate Change (1992)**.

In the absence of detailed waste management legislation and references from Namibia it is suggested that the DPMT Waste Management Procedure should give consideration to South African legislation in this regard. The following would be likely to have applicability to the activities at the Tsumeb Smelter:

- **The National Environmental Management: Waste Act, 59 of 2008**, as amended.
- **Waste Classification and Management Regulations (GN R634 of August 2013, (WCMR))**..
- **National Norms and Standards for the Assessment of Waste for Landfill Disposal (GN R 635 of August 2013)**.
- **National Norms and Standards for Disposal of Waste to Landfill (GN R 636 of August 2013)**.
- **National Norms and Standards for the Remediation of Contaminated Land & Soil Quality (GN R 331 of May 2014)**.
- **List of Waste Management Activities (GN R 921 of November 2013), as amended.**
- **National Norms and Standards for the Storage of Waste (GN R 926 of November 2013)**.
- **Waste Tyre Regulations, (GN R 149 of 2009)**.
- **Regulations Regarding the Planning and Management of Residue Stockpiles and Residue Deposits from a Prospecting, Mining, Exploration or Production Operation (GN R 632 of 2015)**.
- **Regulations to Phase-Out the use of PCB Materials and PCB Contaminated Materials, 2014 (GNR 549 of 10 July 2014).**

As a company with international reach, it is advocated that DPMT should also give consideration to the European Bank for Reconstruction and Development's **performance requirement (PR) 3 for Resource Efficiency and Pollution Prevention and Control**.

Definitions, Terms & Abbreviations:

The definitions used in the DPMT Waste Management Procedure should be updated to match the reference sources used. Such terms and abbreviations must be used correctly and consistently throughout the Waste Management Procedure.

Systems and Infrastructure:

It is recommended to insert such a section into the Waste Management Procedure to define the overriding systems, specific infrastructure and responsibilities with regards to waste management at the Tsumeb Smelter.

Method:

The overall structure, use of terminology and approach advocated in the DPMT Waste Management Procedure must be standardised between sub-sections. It is recommended that a standard template be adopted for the method section to ensure that the appropriate information is presented in a consistent manner that allows for accurate interpretation and implementation. A tabular format may be appropriate. It is recommended that the overall structure of the section be separated into mineralised and non-mineralised wastes and then general and hazardous. Importantly the waste management measures advocated throughout the Method, should be practicable and in line with actual practices and market economics. There must be consistency in the type and colour of waste container advocated throughout the Waste Management Procedure. The hazardous waste section of the Method should include references to the specific requirements for hazardous wastes, most notably arising out of the Waste Classification and Management Regulations (WCMR).

In terms of the South African WCMR, all waste generators must ensure that the wastes they generate are classified in accordance with SANS 10234 within one hundred and eighty (180) days of generation. No evidence was provided to SLR of the current classification of wastes at the Tsumeb Smelter in terms of the WCMR, although there was some evidence of certain of the waste having been assessed in terms of the Minimum Requirements for Waste Disposal by Landfill (2nd Ed, 1998). Such prior classification only remained valid in terms of the WCMR until August 2016. All wastes are now required to be classified (or reclassified) in terms of the WCMR. It is also required to produce Safety Data Sheets for the hazardous wastes generated.

SLR made various specific comments per waste stream section in the Procedure. The key comments are highlighted below:

- The management measures specified should be what is actually occurring and/or what is practicable. The separation of recyclables from the waste stream should be specified.
- Consideration should be given to the degree of separation and sorting that is advocated. This must be relevant to the recycling market and services that are available.
- The waste sorting and separation area should be equipped to manage hazardous waste storage or a specific hazardous waste sorting area must be developed separately.
- Hazardous waste should not be placed on the floor unless in a bunded area.
- Management measures for the Salvage Yard must include awareness of the risks associated with metal containers containing hazardous residues.
- It is noted that crushing of florescent tubes is no longer advocated as best practice. The disposal of florescent tubes to landfill is no longer permitted in terms of South African waste legislation. Current best practice is to recycle all florescent tubes and CFLs.
- If hazardous wastes are to be disposed of at the Hazardous Waste Site in Walvis Bay, a waste manifest document must be generated and proof of safe disposal retained.

- Hazardous wastes should not be combusted in the convertors unless specifically allowed by the approvals under the Atmospheric Pollution Prevention Ordinance.
- The handling and disposal operations for the arsenic dust and bags must be undertaken in terms of the DPMT Hazardous Waste Disposal Site Operations Manual.
- If redundant tyres are stored in any location, the management of such area must be in terms of the Waste Tyre Regulations.
- The nature of hazardous materials destined for sale or offsite use must be declared through a SDS and/or waste manifest document.
- Unless managed though another procedure, it must be specified what wastes can be directed to the sewage treatment plant and what the performance criteria of the sewage treatment plant are.
- A procedure should be developed to ensure the operation and management of the sewage plant is undertaken appropriately.
- Clarity should be provided on whether DMPT has any liability in terms of the tar legacy wastes and the procedure updated accordingly.
- Cognisance should be given to the South African National Norms and Standards for Waste Storage.
- It is suggested to insert a section for the management of garden and food wastes.

Data Management

The Waste Management Procedure should be updated to reflect that data management with respect to waste should be undertaken in terms of the relevant regulations and norms and standards.

3. Review of the Hazardous Waste Landfill

SLR performed a site visit and subsequent design and capacity review of DPMT's Hazardous Waste Disposal Site (HWDS) in order to assess its suitability for DPMT's future requirements and its level of environmental compliance with respect to international best practice.

Liner Suitability and Closure

The liner system is marginally below the South African Department of Water Affairs' (DWAF) minimum requirements in that the HWDS contains a 300mm thick clay layer as opposed to the requisite 600mm. Good practice on site however, as well as the fact that there is no indication of groundwater contamination, suggests that the HWDS is performing adequately and doesn't pose an immediate environmental risk to DPMT. Although an expansion of the site has been approved by the Namibian Environmental Authority, it is recommended that if still possible, that this liner design be amended prior to construction to be in line with international best practice. Furthermore, and in line with best practice, once the HWDS has reached its end of life, it should be adequately capped to ensure it has no future, long term environmental impacts. The capping proposed by Golder is suitable although quantitative demonstration of performance should be illustrated.

Future Capacity

Based on the existing cell airspace, expected future increases in waste volumes, as well as the calculated waste density presented by Golder & Associates, SLR have calculated that the current facility can only receive waste for the next approximately 18 months before reaching full capacity. Furthermore, if the permitted expansion is constructed, a further 6.5 years of disposal time could be realised by DPMT. Three other alternatives to onsite hazardous waste disposal were considered, namely; disposal to a regional, Namibian HWDS, disposal to a South African HWDS and vitrification of the arsenic dust. Given the uncertainties, costs and risks associated with the alternative options, SLR is of the opinion that the expansion of the HWDS would be the most appropriate medium term option and should be pursued as a matter of urgency. Long term, the options proposed need to be further explored before a decision can be made.

Operations

SLR's review of the operations manual, and site visit, illustrated that the HWDS was being managed and operated well. This is further supported by the fact that there appeared to be no definitive contamination of groundwater in the vicinity of the HWDS. It is however recommended that additional dedicated monitoring boreholes be installed to confirm this and for long term monitoring. Additional measures such as covering areas not in use and the use of a dust suppressant could also be implemented to further reduce the risk of environmental contamination.

The currently permitted site is estimated to give DPMT less than 6.5 years of further operational life, assuming an increase in waste production of 80%. This life span could be increased if there is a decrease in waste generation due to either increased operational efficiencies or growth in the market appetite for the vitrification of the flue dust. If hazardous waste generation is not significantly reduced and no regional facility is to be developed, DPMT should investigate a further extension of the HWDS beyond that which has already been approved. 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.

4. Assessment of Current Waste Management Practices

SLR viewed and assessed waste management operations at the Tsumeb facility. Not every site within the facility was inspected, but the key waste management facilities were viewed and discussions held with persons in the Environmental Department. Aspects relating to the hazardous waste site are reviewed in Section 3 and those relating to the Tailings Dams in Section 7. Key comments are as follows:

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 it was evident that significant hazardous and other general wastes were included. Refractory bricks, gas canisters, hydrocarbon drums and paint tins were observed, amongst others. 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 is a significant cause of concern and its operation is likely to be resulting in impacts to the environment as well as occupational health risks. The site has no facilities to enable the appropriate management of general waste (also see Section 4.1). There was evidence of the active management of hazardous waste streams at the site (separation of Tyvek suits and other materials). 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. None of the site operations are in line with best practice for waste management. It is recommended that:

- Management and operations of this general waste handling area need to be revised as a 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 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 neither be appropriate for DPMT to dispose of waste at that facility. The alternative for DPMT to undertake responsible disposal of general waste f 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.

Sewage plant:

It is understood that the sewage plant is relatively new and therefore anticipated to be adequate to manage the sewage requirements of the DPMT. The plant was however not operational at the time of the review. The sewage plant should be restored to operation as soon as is possible. Appropriate health and safety signage as well as environmental monitoring is recommend for the lagoon/reed bed near the calcine dump where untreated effluent is being pumped.

Tar pits:

Evidence exists of a number of historical tar disposal pits on the site. Some have been consolidated to a single location but a number of separate sites still exist. A study by Jones and Wagener (JW181/09/C391, Revision 2) suggests that these deposits (or at least the consolidated site (tarpit)) are unlikely to cause hydrocarbon pollution. SLR note that GCS (15-642 of April 2016) recommended the implementation of a monitoring program for hydrocarbons in groundwater.

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. It is understood that DPMT have conducted an assessment for the remediation of the storm water management systems. It is recommended that the any such assessment give consideration to the containment of contaminated surface water runoff arising from the waste management facilities at the Tsumeb Smelter.

General Waste Landfill Site:

DPMT had applied to and obtained environmental clearance from the MET (dated 9 August 2013) for the establishment of a General Waste Landfill Site at the Tsumeb Smelter. It is evident to SLR that the current general waste handling area is not in any way, shape or form the General Waste Landfill Site that was designed, assessed and approved by the MET and that such landfill site was never developed. DPMT indicated that it did not develop the approved General Waste Landfill Site due to the establishment of the sulphuric acid plant being prioritised at the time. Such environmental clearance has expired. As part of the current EIA process for the Smelter Optimization and Upgrade Project it is proposed to cover the development of the General Waste Landfill Site under the Amended ECC.

Due to the General Waste Landfill Site not being established, general waste management operations at the Tsumeb Smelter are likely to be resulting in human health risk as well as contributing to environmental pollution (see previous discussion in Section 4 in this regard). Although in the cumulative context of the Tsumeb Smelter it is likely that many of these impacts would 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 General Waste Landfill Site is constructed, or measures are implemented to enable sanitary general waste management at the Tsumeb Smelter.

It is recommended that the development of the General Waste Landfill Site be undertaken as soon as possible. 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 arisings at the Tsumeb Smelter. Refer to Section 9 for a high-level cost benefit analysis between a General Waste Landfill Site and a general waste incinerator.

5. Laboratory Waste Management Practices

It is understood that the 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.

6. Review of Recycling Practices

Very limited recycling is undertaken at the DPMT. Other than the active recycling of scrap metal, SLR did not observe any meaningful recycling practices at the DPMT. 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 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.

Future recycling programmes at the DPMT should give consideration to:

Waste Reduction and Minimisation: as arguably the most effective means of managing waste. These measures focus on reducing or eliminating the generation of waste at the source, which is in contrast to the balance of the waste management hierarchy that focuses on processing waste after it is created. This typically requires efforts to minimize resource and energy use during production so that, for the same output, fewer materials are used and less waste is produced. Potentially available techniques for consideration include:

- Education and awareness;
- Efficiency and resource optimisation;
- Improved quality control and process monitoring; and
- Extended producer responsibility.

Any Re-use and Recycling must:

(a) use less natural resources than disposal of such waste; and

(b) to the extent that it is possible, is less harmful to the environment than the disposal of such waste.

The recycling of scrap metal, glass, paper and cardboard, plastic and organic materials can be facilitated though source separation, collection and storage of the materials. The wastes can be made available to 3rd parties who facilitate or specialise in the re-use or recycling of particular waste streams. Prior to any re-use or recycling of waste, it is essential that DPMT ensure that the waste is appropriately recorded, is *fit-for-purpose* and safe for the proposed use. DPMT, as the waste generator, also has an obligation to ensure that any waste recyclers operate in manner that does not pose significant risks to human health or the environment. Residual waste produced by the recyclers must be appropriately managed.

7. Impacts of Historic Wastes

The historic or legacy wastes stockpiled or disposed around the DPMT site are understood to comprise mostly slags, arsenic calcines and dusts. These have been generated over decades of operation at the Smelter and are widely distributed across the site. Almost none of the legacy wastes are located in facilities that are designed or managed in terms of best practice. The nature of these materials is such that they may be hazardous and may have, or continue to, resulted in environmental pollution and degradation. It is understood by SLR that, in terms of an agreement with the MET, DMPT is not responsible or liable for impacts caused by the legacy wastes, other than the arsenic calcines.

The chemistry of each legacy waste stockpile is not known to SLR but it is understood that the composition of each could vary considerably (both between and within stockpiles). Jones and Wagener (JW 49/01/7818 in 2001 and JW 48/11/C391 in 2011) investigated the contamination risks to groundwater at the Tsumeb Smelter. Samples of the slags and calcines were subject to the Acid Rain Leach Procedure and compared to the Acceptable Environmental Risk levels from the Minimum Requirements (DWAF, 1998). In general JAWs found that the slags would pose a relatively low risk to groundwater, due largely to the low mobility of chemicals of concern. The baghouse dust and calcines were however noted to pose a significant risk to soils and groundwater and the removal of these materials to the Hazardous Waste Disposal Site (HWDS) was recommended.

To SLR's knowledge the disposal of the legacy baghouse dust and calcines stockpiles to 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 failure to dispose of the arsenic calcine legacy wastes to the HWDS is a non-compliance with the EMP. It is known that there is no longer airspace available in the current phase of the HWDS to receive all of the legacy baghouse dust and calcines stockpiles, thus an alternative solution is required. See Section 3.6.

8. Review of the Tailings Facility

SLR did not perform a formal, comprehensive assessment of the tailings dam in terms of long term risk mitigation/stability but only a brief site visit in order to support the overall waste management review. The major problems identified, which DPMT is already aware of are:

- the major erosion that has taken place on the side walls of the dam,
- contamination of the soil and groundwater immediately beneath the tailings dam that has taken place due to the facility not being lined, evidenced by the GCS DPMT Tailings Leachate and Tsumeb Smelter Groundwater Model Update Reports (GCS, 2016).

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. 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.

9. Cost benefit Analysis of Incinerator vs landfill for general waste on site

A high level cost comparison between the construction of a dedicated general waste landfill on site and the installation of a waste incinerator was performed by SLR. Three scenarios were assessed:

1. Cost-effective incinerator with nominal gas cleaning and fuel usage to ensure complete combustion;
2. Cost-effective incinerator with nominal gas cleaning and zero fuel usage;
3. Cost-effective incinerator with no gas cleaning or fuel usage

Using a project lifetime of 24 years, the net present cost for the landfill (inclusive of closure) and the incinerator, for each of the above mentioned scenarios, are presented in the table below.

	Scenario 1	Scenario 2	Scenario 3
Landfill	N$ 3 410 153	N$ 3 410 153	N$ 3 410 153
Incinerator	N$ 22 190 678	N$ 6 967 095	N$1 417 095

In essence, although an incinerator would present a seemingly elegant solution to DPMT's on site general waste disposal requirements, the use of an incinerator brings with it the added complication of flue gas emissions and the need to treat these – if DPMT intends to keep in line with international best practice. The addition of flue gas scrubbing to the system requires an additional approximately N$6 million. This increased capital expenditure, as well as the fuel costs required to effectively run the incinerator, makes it a far more expensive option than landfilling.

10. Contribution to the EIA

Waste management is one of many activities undertaken at the Tsumeb Smelter which may have impacts on environmental attributes. As a result of the long history of operations and complexity of the site's layout it is challenging to determine and apportion the source of detected impacts on environmental attributes to specific activities. Thus no attempt has been made in this report to assign impacts to specific waste management activities. The section highlights key considerations that should be addressed in the EIA and EMP for the Smelter Optimization and Upgrade Project:

1. Current Operations:
    a. General and hazardous wastes must be separated at source across the Tsumeb Smelter operations.
    b. A 'general waste handling area' (or areas) must be formalised and developed with facilities appropriate to the type and volume of wastes being received and processed.
    c. The 'waste handling area' should be equipped to manage specific hazardous waste streams or a specific hazardous waste sorting area (or areas) must be developed separately.
    d. The open-air burning of general waste must be stopped and a solution implemented for the disposal of the residual general wastes. This development must be viewed as urgent by DPMT and prioritised.
        i. The above could be the General Waste Landfill Site as previously proposed or a modern general waste incineration facility. For the former, it is recommended that the renewal of the environmental clearance from the MET be secured It is recommended that all details from the EMP submitted for the General Waste Landfill Site be included in the current EIA and EMP for the Smelter Optimization and Upgrade Project.
        ii. For the latter the feasibility and design of a general waste incineration facility must be undertaken and a process to secure environmental clearance from the MET commenced immediately.
    e. Repair and then operate the Sewage Treatment Plant as soon as possible. Once operational the current area for effluent discharge should be rehabilitated to remove sewage contaminant risks.

f. Management of the HWDS should continue as per current approval conditions and protocols, with the addition of more focussed groundwater and air quality monitoring programmes for the HWDS;
g. Management of other hazardous wastes not disposed to the HWDS needs to be improved.
    i. DPMT must classify, in terms of the Globally Harmonised System (SANS 10234), all wastes.
    ii. DPMT must ensure the labelling of containers and Safety Data Sheets for all hazardous wastes.
    iii. DPMT must ensure chain of custody records/waste manifest documents for each hazardous waste departing the Tsumeb Smelter
    iv. DMPT must audit each of the external service providers to ensure that those waste management operations are legally compliant.
h. DPMT management must be aware of the capacity constraints of the HWDS and must investigate and implement solutions for providing hazardous waste management or disposal capacity timeously.
i. DPMT should consider implementing a Corporate Social Initiative project in order to enable the establishment of one or more initiatives for the re-use or 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.

2. Construction of Smelter Expansion:
    a. During construction it is likely that around 200 additional staff will be present on site for a period of up to 2 years. These contractors and their activities will result in a significant increase in the generation of wastes. The waste management systems at the Tsumeb Smelter are currently constrained and unable to handle additional volumes. DPMT must either provide capacity in their waste management systems to accommodate this, or specify that each contractor is responsible for their own waste management. If the latter, DMPT must ensure that the contractor's actions comply with waste management legislation and best practice.
3. Future operations:

DPMT management must be aware that the Arsenic Plant termination and Smelter Expansion will increase hazardous waste production, thereby furthering reducing the life of the HWDS (see Section 3.4). Solutions for providing hazardous waste management or disposal capacity must be investigated and implemented timeously. In this regard DPMT are advised to note that determining the feasibility of; securing environmental clearance for; and constructing any substantive waste management solution is likely to take 2 to 3 years. SLR recommends that authority approval of the Smelter Expansion be concomitant to the implementation of an appropriate hazardous waste management solution(s).

DPMT WASTE MANAGEMENT REVIEW

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LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

Below a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	**Definition**
CFL	Compact Fluorescent Light
DPMT	Dundee Precious Metals Tsumeb
DWAF	South African Department of Water Affairs (formerly)
ECC	Environmental Clearance Certificates
EIA	Environmental Impact Assessment
GHS	Globally Harmonized System
HWDS	Hazardous Waste Disposal Site
LC	leachable concentration
MET	Ministry of Environment and Tourism
PPE	Personal Protective Equipment
PR	Performance Requirement
POPs	persistent organic pollutants
SLR	SLR Consulting
TC	total concentration
UNFCCC	United Nations Framework Convention on Climate Change
WCMR	Waste Classification and Management Regulations

DPMT WASTE MANAGEMENT REVIEW

1 INTRODUCTION

The Tsumeb Smelter, currently owned and operated by Dundee Precious Metals Tsumeb (DPMT), a subsidiary of Dundee Precious Metals Incorporated (Dundee), is located on the outskirts of Tsumeb in the Oshikoto Region of Namibia, approximately 2 km North East of the town centre. 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, Kapan, Armenia and Opuwo, Namibia for processing in the smelter. The smelter has an annualized capacity of 240,000 tpa of copper concentrates.

DPMT is currently considering plans for an increase in processing capacity of the Tsumeb Smelter. DPMT has appointed Worley Parsons to undertake the basis of design for the proposed Upgrade and Optimisation Project in order to increase the throughput capacity from 240 000 tpa to 370 000 tpa concentrate smelted.

DPMT currently holds a number of Environmental Clearance Certificates (ECC) in terms of the Environmental Management Act, 2007 for the smelter operations in Tsumeb. These include:

- Smelter operations - 1 March 2010, renewal in September 2016;
- Hazardous Waste Site – 29 September 2009;
- Sewage Treatment Plant – 20 June 2014;
- 11 kV Power line – 18 June 2014;
- Contractor's camp sewage treatment plant – 1 July 2014
- Sulphuric Acid Plant – 9 January 2014;
- General Waste Site – 9 August 2013, now expired
- Use of the Kliplime Quarry – ~ 2013.

The proposed smelter Upgrade and Optimisation Project requires the amendment of some of the project components approved under the previous ECC. DPMT appointed SLR Environmental Consulting (Namibia) (Pty) Ltd (SLR) to undertake the required Environmental Impact Assessment Amendment process. The process also includes the compilation of a consolidated Environmental Management Plan for all operations (current and proposed) at the smelter.

SLR was also appointed to provide a high-level overview and professional opinion on current waste management strategies and operational procedures at their Tsumeb Smelter, including for both general and hazardous waste. The scope of work included the following:

- Assessment of the site's general waste management strategies including disposal, classification and recycling relative to national and international legislation and best practice.
- Assessment of the general design and operation of the hazardous waste site, including any future risks related to the design and current and future stored volumes of arsenic waste.
- Assessment of current practice and possible impacts of waste not currently accommodated for by management practices at the site; inclusive of a review of the storage of both produced and used chemicals.
- A review of laboratory waste management procedures.
- Review of and recommendation on the site's recycling practices and potential as well as any related impacts.
- Consideration and assessment of point and nonpoint impacts of exposed material stockpiles on the smelter property (undertaken with input from the surface and groundwater study results).
- Assessment and review of the tailings facilities and their contribution to the overall waste load.
- Contribution to the EIA process to identify the waste related issues, interrogate if the waste management systems have capacity to handle increased waste arising from the proposed smelter capacity increase and to recommend mitigation measures for general and hazardous waste management.

2 REVIEW OF WASTE MANAGEMENT STRATEGIES

Waste management at the Tsumeb Smelter is undertaken in terms of a Waste Management Procedure as well as various related policies and procedures. The actual management of waste generated at the various facilities is shared between the generator (area owners) and the nominated waste manager or contractor, with oversight by the Environmental Department at DPMT.

It is understood that the Waste Management Procedure (P-446-4-4-Waste Management. 29/06/2016) is currently under review by DPMT. SLR has reviewed the draft DPMT Waste Management Procedure and has the following comments:

2.1 PURPOSE:

It is suggested that the purpose of the DPMT Waste Management Procedure should extend beyond the "disposing of waste" and rather reference the "management of waste in terms of the waste management hierarchy" or the "management of waste in terms of appropriate best practice". The motivation for this being that disposal should be the last option in modern waste management practices. Adoption of the waste management hierarchy principles is considered environmental best practice and the Waste Management Procedure should be structured to facilitate implementation of these practices.

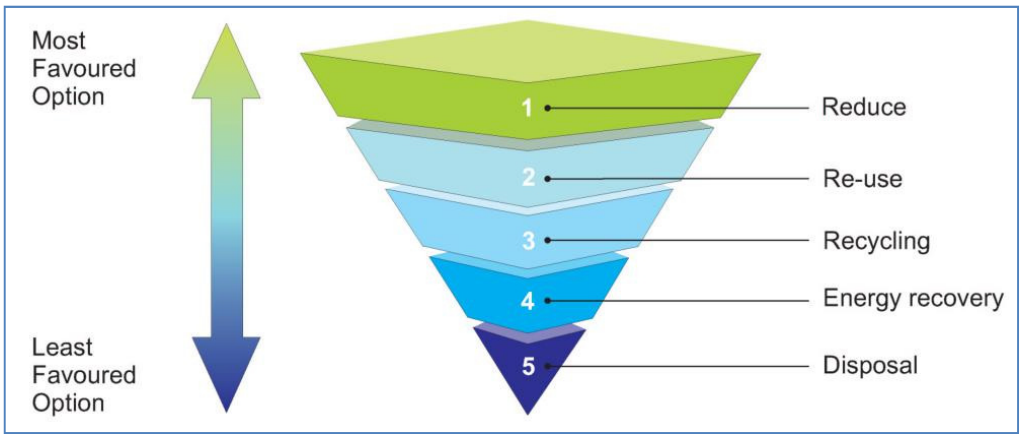

FIGURE 2-1: THE WASTE MANAGEMENT HIERARCHY

International environmental best practice also advocates the application of the following principles with regards to waste management:

- Polluter pays principle: is the commonly accepted practice that those who produce pollution should bear the costs of managing it to prevent damage to human health or the environment;
- Proximity principle: aims to ensure that potentially harmful effects of an activity are managed as near to the source as possible; and the
- Precautionary principle: sets out that a risk-averse and cautious approach should be applied, which gives consideration to the limits of current knowledge about the consequence of decisions and actions.

Waste management at the Tsumeb Smelter in general and the DPMT Waste Management Procedure in particular should give consideration to the integration of these principles.

2.2 SCOPE:

It is suggested that the scope of the Waste Management Procedure be broadened to "all activities that generate waste or involve the management of waste at the Tsumeb Smelter". The scope should include "activities on land managed …".

Depending on the approach adopted by DPMT, consideration could be given to this Waste Management Procedure excluding the management of mineralised wastes (e.g. being any waste derived from or incidental to the mining or processing of a mineral and which is stockpiled, stored or accumulated for re-use or is disposed of), if the mineralised wastes are adequately managed through other DPMT procedures. Alternatively the Method section of the Waste Management Procedure must be updated to provide for the management of the various mineralised wastes generated at the Tsumeb Smelter.

It is recommended that DPMT develop a Waste Register in which all wastes generated across all facilities and operations at the Tsumeb Smelter are documented. All identified wastes documented in the

Waste Register should be cross referenced to the Method section in the Waste Management Procedure to ensure that provision is made for every waste stream. The waste register should also provide for record keeping (e.g. chain of custody) for all wastes removed from site. The Waste Register should be reviewed annually or whenever an operation at the Tsumeb Smelter is changed and a new waste stream is generated.

2.3 REFERENCE:

Waste management at the Tsumeb Smelter in general and the DPMT Waste Management Procedure in particular should, as a minimum, aim to ensure compliance with relevant Namibian legislation. The Namibian Constitution (Article 95) sets out that the State shall actively promote and maintain the welfare of the people by adopting, inter alia, policies aimed at: “maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future; in particular, the Government shall provide measures against the dumping or recycling of foreign nuclear and toxic waste on Namibia territory. Article 91(c) assigns to the Ombudsman the duty to investigate complaints concerning the over-utilisation of living natural resources, the irrational exploitation of non-renewable resources, the degradation ad destruction of ecosystems and failure to protect the beauty and character of Namibia.

The Environmental Management Act promotes the sustainable management of the environment and use of natural resources. The principles of environmental management set out in the Act [Article 3(2)((i)] include that “the reduction, re-use and recycling of waste must be promoted”. Article 5 of the Act provides for regulation on matters in respect of waste, including that a person may not discard or dispose of waste, except (a) at a disposal site declared or approved by the Minister or (b) in a manner or by means of a facility or method and subject to such conditions as the Minister may prescribe. A list of activities which may not be undertaken without an ECC has been published by the Ministry of Environment and Tourism (MET). With regard to waste management, treatment, handling and disposal, the activities requiring an ECC include:

- The construction of facilities for wastes sites, treatment of waste and disposal of waste;
- Any activity entailing a scheduled process referred to in the Atmospheric Pollution Prevention Ordinance of 1976; and
- The import, processing, use and recycling, temporary storage, transit or export of waste.

Namibia is also developing further legislation to regulate waste management and public health as reflected in the Pollution Control and Waste Management Bill (circa 2003) and the Public and Environmental Health Bill (2014). The DPMT Waste Management Procedure should give consideration to the intentions of these Bills in as much as this is feasible.

Namibia is a signatory to a number of multilateral environmental agreements, which when considered in conjunction with Article 144 of the Constitution mean that such conventions form part of the law of Namibia. The DPMT Waste Management Procedure should give effect to the requirements of these agreements where possible.

- The **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)** is an international treaty designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries. The convention also includes stringent requirements for notice, consent and tracking for movement of wastes across national boundaries.
- The **Stockholm Convention on Persistent Organic Pollutants (2001),** effective from May 2004, aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). Parties to the convention agreed to a process by which persistent toxic compounds can be reviewed and added to the convention, if they meet certain criteria for persistence and transboundary threat. The first new chemicals to be added to the Convention were agreed at a conference in Geneva on 8 May 2009.
- The **United Nations Framework Convention on Climate Change (1992)** (UNFCCC) is an international environmental treaty that entered into force in March 1994 with the objective to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

The Council of the Municipality of Tsumeb has made regulations relating to refuse removal, littering and dumping (N 33 of February 2005). These regulate the management of domestic refuse in the municipal area and the council's provision of services in this regard.

In the absence of active and detailed waste management legislation and references from Namibia it is suggested that the DPMT Waste Management Procedure should give consideration to South African legislation, regulation and norms and standards and/or international standards. The following South African legislation would be likely to have applicability to the scope of activities at the Tsumeb Smelter:

- The **National Environmental Management: Waste Act, 59 of 2008**, as amended.

- **Waste Classification and Management Regulations (GN R634 of August 2013, (WCMR))**. The purpose of the WCMR is to ensure adequate and safe storage and handling of hazardous waste, and to inform the consideration of suitable waste management options. These regulate the classification of waste in terms of SANS 10234; prescribe requirements for the assessment of waste destined for disposal (GN R 635); require that disposal of waste to landfill take place in terms of GN R 636; prescribe requirements and timeframes for the management of certain wastes and prescribe the general duties of waste generators, transporters and managers. They also include communication elements for labelling and information required for Safety Data Sheets.
- **National Norms and Standards for the Assessment of Waste for Landfill Disposal (GN R 635 of August 2013)**. These prescribe the requirements for the assessment of waste prior to disposal to landfill. Waste generators must ensure their waste is assessed in terms of the standard prior to disposal. The assessment is based on the total concentration (TC) and leachable concentration (LC) of certain elements and chemical substances in the waste compared against concentrations specified in the standard. Following laboratory analysis, the TC and LC are compared with specific TC and LC threshold values in the standard, which then determines the particular type of waste (Type 0, 1, 2, 3 and 4) for disposal.
- **National Norms and Standards for Disposal of Waste to Landfill (GN R 636 of August 2013)**. These determine the requirements for the disposal of waste to landfill, define landfill classification and containment barrier designs, waste acceptance criteria for landfills and certain restrictions on waste disposal. Four new classes of landfill (Class A, B, C or D) are prescribed in the standard, each with a particular barrier (liner) design. The new landfill classes do not make a distinction between sites for the disposal of general or hazardous waste. The standard stipulates which types of waste are allowed to be disposed at a particular class of landfill. Waste disposal prohibitions, aimed at eliminating the disposal of certain wastes within set periods of time include certain hazardous wastes, recoverable materials such as used oils and solvents, liquid wastes and brines, as well as high calorific value wastes.
- **National Norms and Standards for the Remediation of Contaminated Land & Soil Quality (GN R 331 of May 2014)**. These provide a uniform approach to determine the contamination status of an investigation area; limit uncertainties regarding the criteria and methods to apply in assessment of contaminated land and provide minimum standards for assessing environmental protection measures for remediation activities.
- **List of Waste Management Activities (GN R 921 of November 2013), as amended.**

  These set out, in three categories, the waste management activities that no person may commence, conduct or undertake unless a waste management licence has been issued in respect of such activities.

- **National Norms and Standards for the Storage of Waste (GN R 926 of November 2013)**. These provide a uniform approach to the management of waste storage facilities, aim to ensure best practice in the management of waste storage facilities and provide minimum standards for the design and operation of facilities.
- **Waste Tyre Regulations, (GN R 149 of 2009)** provide regulatory mechanisms for the management of waste tyres.
- **Regulations Regarding the Planning and Management of Residue Stockpiles and Residue Deposits from a Prospecting, Mining, Exploration or Production Operation (GN R 632 of 2015)**. The purpose of these Regulations is to regulate the planning and management of residue stockpiles and residue deposits from a prospecting, mining, exploration or production operation. The Regulations are not directly applicable to waste disposal operations at a smelter (as it is not a mine), but certain of the principles may be applicable to facilities managing mineralised wastes.
- **Regulations to Phase-Out the use of PCB Materials and PCB Contaminated Materials, 2014 (GNR 549 of 10 July 2014).** The purpose of these Regulations is to prescribe requirements for the phase-out of the use of PCB materials and PCB contaminated materials to ensure that impacts or potential impacts on health, well-being, safety and the environment are prevented or minimised.

As a company with international reach, it is advocated that DPMT should also give consideration to the European Bank for Reconstruction and Development's performance requirements with relevance to waste management. This includes **Performance Requirement (PR) 3: Resource Efficiency and Pollution Prevention and Control** which is explained as follows:

- The Performance Requirement recognises that increased economic activity and urbanisation can generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels. Therefore, resource efficiency and pollution prevention and control are essential elements of environmental and social sustainability and projects must meet good international practice in this regard. This PR outlines a project-level approach to resource management and pollution prevention and control, building on the mitigation hierarchy, the principle that environmental damage should as a priority be rectified at its source, and the "polluter pays" principle. The project-related impacts and issues associated with resource use, and the generation of waste and emissions need to be assessed in the context of project location and local environmental conditions
- Avoid or minimise the generation of hazardous and non-hazardous waste materials and reduce their harmfulness as far as practicable. Where waste generation cannot be avoided but has been minimised, reuse, recycle or recover waste, or use it as a source of energy; where waste cannot be recovered or reused, treat and dispose of it in an environmentally sound manner.

- If the generated waste is considered hazardous, assess technically and financially feasible and cost-effective alternatives for its environmentally sound disposal considering the limitations applicable to transboundary movement and other legal requirements.
- When waste disposal is transferred offsite and/or conducted by third parties, obtain chain of custody documentation to the final destination and use contractors that are reputable and legitimate enterprises licensed by the relevant regulatory agencies. Also ascertain whether licensed disposal sites are being operated to acceptable standards. Where this is not the case, consider alternative disposal options, including the possibility of developing own recovery and disposal facilities at the project site.

2.4 DEFINITIONS, TERMS & ABBREVIATIONS:

If the additional references detailed in the preceding section are adopted then the definitions used in the DPMT Waste Management Procedure should be updated to match these sources. The terms and abbreviations must be used correctly and consistently throughout the Waste Management Procedure and related policies and procedures.

2.5 SYSTEMS AND INFRASTRUCTURE:

It is recommended to insert an additional section into the Waste Management Procedure to define the overriding systems, specific infrastructure and responsibilities with regards to waste management at the Tsumeb Smelter. This new section could include:

- cross reference to the Waste Register referred to in the Scope above;
- the identification of the waste management facilities referenced in the Waste Management Procedure;
- the identification of the types and colours of bins and skips;
- requirements for waste container labelling;
- information on waste removal intervals;
- the wastes classification and assessment regimes adopted;
- requirements for Safety Data Sheets for wastes;
- requirements for waste manifest documents for hazardous wastes leaving the Tsumeb Smelter;
- commitments in terms of training and awareness with regards to waste; and
- details of the key departments and personnel responsible for waste management.

2.6 METHOD:

The overall structure and information presented in the DPMT Waste Management Procedure varies significantly between the sub-sections. The terminology used also varies, as does the approach that is

advocated. It is recommended that a standard template be adopted for the document to ensure that the appropriate information is presented in a consistent manner that allows for accurate interpretation and implementation. The following template headings are suggested for each sub-section:

Waste name/ Classification/ Generator/Stored at source in/ Taken to/ Recycling method/ Disposal method/ Assessment result/ Requirements or Exceptions/ PPE/ Handling Procedures/ Pictures/ Department or Contractor/ Contact person/ Responsible person. A tabular format may be appropriate. An example of the potential layout and content is provided below:

Waste name:			
Generator:		Classification result:	
Storage requirements and location:		Generator contact person:	
To be taken to:		Frequency of removal:	
Waste manager contact person:		Recycling method:	
Disposal method:		Assessment result:	
PPE requirements:			
Handling Procedures:			
Requirements or Exceptions:			
SDS file name or reference			
Pictures			

It is recommended that the overall structure of the Method section in the DPMT Waste Management Procedure should separate mineralised and non-mineralised wastes and then general and hazardous wastes into distinct sections.

The waste management measures advocated throughout the Method, be it sorting, recycling or disposal, should be practicable and in line with actual practices and market economics. It is pointless to advocate

management that is not or indeed cannot be undertaken. The caveat to this being if there are reasonable and feasible plans in place to implement new management measures in future.

The hazardous waste part of the Method section should include references to the specific requirements for hazardous wastes, most notably arising out of the Waste Classification and Management Regulations. These being the:

- classification of such wastes (see Section 2.3.1 below),
- appropriate labelling of the containers,
- safety data sheets,
- measurement and recording of waste volumes, and
- waste manifest documents for each waste that will leave the DPMT site.

There must be consistency in the type and colour of waste container advocated throughout the Waste Management Procedure.

2.6.1 CLASSIFICATION OF WASTES:

In terms of the South African WCMR, all waste generators must ensure that the wastes they generate are classified in accordance with SANS 10234 within one hundred and eighty (180) days of generation. Wastes listed in Annexure 1 of the WCMR need not be classified. Wastes must be re-classified every five (5) years, or within 30 days of modification to the process or activity that generated the waste, changes in raw materials or other inputs, or any other variation of relevant factors. SANS 10234 is the latest edition of the South African National Standard Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

No evidence was provided to SLR of the current classification of wastes at the Tsumeb Smelter in terms of the WCMR, although there was some evidence of certain of the waste having been assessed in terms of the Minimum Requirements for Waste Disposal by Landfill (2nd Ed, 1998). Such prior classification remained valid in terms of the WCMR until August 2016. However all wastes are now required to be classified (or reclassified) in terms of the WCMR. Neither was there evidence of Safety Data Sheets for the hazardous wastes generated at the Tsumeb Smelter. The relevant classification results for each waste stream and the date completed should be documented in the Waste Register.

2.6.2 COMMENTS PER WASTE STREAM

SLR has the following specific comments per waste stream section:

<u>Cardboard, newspaper. paper:</u>
This should be a subsection within domestic waste.

The management measures specified should be what is actually occurring and/or what is practicable.

Domestic waste:

The management measures specified should be what is actually occurring and/or what is practicable. The separation of recyclables from the waste stream should be specified.

Reference needs to be made of the specific waste sorting and separation site and final disposal site to be used. Given that very little recycling takes place, the disposal of general waste is a vital component of general waste management at the Tsumeb Smelter site. This section must be updated to ensure that management and disposal of the general waste stream is undertaken appropriately.

Toner and print cartridges:

The included measures are adequate.

Glass, bottles, cans and plastic cool drink bottles:

This should be a subsection within domestic waste.

Consideration should be given to the degree of separation and sorting that is advocated. This must be relevant to the recycling market and services that are available.

No potentially hazardous containers (e.g. empty containers from the laboratory) should be mixed with this waste stream. Restrictions should be placed on where and how these bottles are cleaned.

Plastic containers/chemical drums:

The measures advocated here are contradictory as they are defined as hazardous wastes and then directed to be mixed with plastic recyclables. This is not appropriate and must be changed.

If there is a risk that these containers contain traces of hazardous materials then they should be managed as hazardous waste. Such containers (with holes in them) should not be placed on the floor unless in a bunded area. The waste sorting and separation area should be equipped to manage such hazardous waste storage or a specific hazardous waste sorting area must be developed separately.

Paint drums:

Such containers (with holes in them) should not be placed on the floor unless in a bunded area. The waste sorting and separation area should be equipped to manage such hazardous waste storage or a specific hazardous waste sorting area must be developed separately.

Depending on volumes of empty paint drums, an on-site crusher and baler could be considered.

Metal drums:

A distinction must be made for drums that contained hazardous materials versus those that didn't. Drums of unknown provenance should be assumed to have contained hazardous materials. All drums that contained hazardous chemicals may only be stored on bunded areas.

If such drums are to be cleaned then restrictions should be placed on where and how these drums are cleaned such that the dirty water is managed.
Management measures for the Salvage Yard must include awareness of the risks associated with drums potentially containing hazardous residues.

Scrap metal:
No metal containers with hydrocarbon or hazardous material contamination to go to scrap without being drained (transformers, gearboxes etc).
Restrictions should be placed on where and how these scrap metals are cleaned.
Management measures for the Salvage Yard must include awareness of the risks associated with metal containers containing hazardous residues.

Florescent Tubes:
This section should be expanded to specifically include the management of compact fluorescent lights (CFL).

It is noted that crushing of florescent tubes is no longer advocated as best practice. As of 23 August 2016, the disposal of florescent tubes to landfill is no longer permitted in terms of South African waste legislation. Current best practice is to recycle all florescent tubes and CFLs. These should be collected and placed in cardboard boxes for collection by an approved recycler who can manage these appropriately.

If crushing and disposal remains the only viable alternative for the florescent tubes, the methodology should be improved so that the drums containing crushed tubes are not open or opened on site.
The waste sorting and separation area should be equipped to manage hazardous wastes or a specific hazardous waste sorting area must be developed separately. If florescent tubes are to be disposed of at the Hazardous Waste Site in Walvis Bay, a waste manifest document must be generated and proof of safe disposal retained.

Oily rags and used PPE:
The waste sorting and separation area should be equipped to manage hazardous wastes or a specific hazardous waste sorting area must be developed separately. Hazardous Personal Protective Equipment (PPE) should not be combusted in the convertors unless specifically allowed by the approvals under the Atmospheric Pollution Prevention Ordinance Alternative options for disposal need to be investigated and implemented as a priority.

Arsenic dust and bags:
The arsenic dust is ‘disposed’ of at the hazardous waste site and not ‘stored’ on site as indicated.
Any storage of the arsenic wastes prior to disposal should only be done in a bunded area.

The procedure should specify that waste handling and disposal operations for the arsenic dust and bags must be undertaken in terms of the DPMT Hazardous Waste Disposal Site Operations Manual.

Waste oil and hydrocarbon contaminated soils:

Used oil is hazardous and should not be stored in a general waste yard. The waste sorting and separation area should be equipped to manage hazardous wastes or a specific hazardous waste sorting area must developed separately.

Oils should only be stored in containers that are in good condition.

Any container with used oils may only be stored in bunded areas or on drip trays.

If taken off-site by a recycler, a waste manifest document must be generated and proof of safe disposal retained.

It is recommended that the management and clean-up of spillages should be dealt with in a specific Procedure. Only the management of contaminated consumables and soils should be included in this Procedure.

Pallets:

It should be specified where broken wooded pallets are to be burned.

Mega/bulk bags:

It should be specified that bags contaminated by hazardous materials may not be reused for the sorting or storage of general wastes.

Redundant chemicals:

Containers with redundant chemicals may only be stored in bunded areas or on drip trays.

A method is to be specified for how the risk of handling these materials are to be classified.

Redundant chemical management could be integrated with the Hazardous Materials & Chemical Management Procedure.

If disposed to the Hazardous Waste Site in Walvis Bay, a waste manifest document must be generated and proof of safe disposal retained.

Used batteries:

It should be specified that used batteries constitute a hazardous waste. The waste sorting and separation area should be equipped to manage such hazardous wastes or a specific hazardous waste sorting area must be developed separately. Batteries or containers with batteries may only be stored in bunded areas or on drip trays.

Options for battery recycling should be explored.

If disposed to the Hazardous Waste Site in Walvis Bay, a waste manifest document must be generated and proof of safe disposal retained.

Tyres:

If redundant tyres are stored in any location, the management of such area must be in terms of the Waste Tyre Regulations.

Oil Filters:

It should be specified that oil filters constitute a hazardous waste.

Specify what the oils are drained into or reference the Waste Oil section.

Containers with oil filters may only be stored in bunded areas or on drip trays.

Oil filters are hazardous and should not be stored in a general waste yard. Oil filters should only be stored in containers that are in good condition.

If disposed to the Hazardous Waste Site in Walvis Bay, a waste manifest document must be generated and proof of safe disposal retained.

Air Filters:

Yellow skips are for hazardous wastes and should not be taken to the general waste yard.

If such separation is happening on site then measures must be specified to ensure they are undertaken appropriately.

Refractory bricks:

It is understood that used refractory bricks are hazardous. The procedure for storing, handling and reusing these should be updated to reflect this.

Any sale or offsite use would require the hazardous nature of these materials to be declared through a SDS and/or waste manifest document.

Fire assays:

It is understood that used assays are hazardous wastes. The procedure for storing, handling and reusing these should be updated to reflect this.

Biomedical waste:

Bio-medical waste should not be combusted in the convertors unless specifically allowed by the approvals under the Atmospheric Pollution Prevention Ordinance. Alternative options for disposal need to be investigated and implemented as a priority.

Acid plant:

The weak acid stream from the Acid Plant is to be treated at the Effluent Treatment Facility.

Solid wastes (filter cake sludge and spent vanadium pentoxide catalyst) from the Acid Plant may only be stored in bunded areas.

If disposed to the hazardous waste site then reference the DPMT Hazardous Waste Disposal Site Operations Manual.
If disposed to the Hazardous Waste Site in Walvis Bay, a waste manifest document must be generated and proof of safe disposal retained.

Electrical cables:
It must be specified where these materials are collected/stored prior to disposal. The cables should not be combusted in the convertors unless specifically allowed by the approvals under the Atmospheric Pollution Prevention Ordinance. Alternative options for disposal need to be investigated and implemented.

E-waste:
It must be specified where are these materials are collected/stored prior to disposal. It must be specified how these wastes are managed beyond storage.
Any collection or offsite use would require the hazardous nature of these materials to be declared through a SDS and waste manifest document.

Waste Water:
It is recommend that that the Domestic waste water and Tailings return water are dealt with separately, as the tailings water presumably does not go to the sewage plant.
Unless managed though another procedure, it must be specified what wastes can be directed to the sewage treatment plant and what the performance criteria of the sewage treatment plant are. This section must be updated to ensure the operation and management of the sewage plant is undertaken appropriately, or a separate Procedure developed. Such Procedure should detail the emergency measures in case of a failure of the sewage treatment plant.

It must be specified where the treated sewage sludge is disposed of.

Ion exchange resins:
It must be confirmed whether this material is classified as a hazardous waste.
If so, the procedure for storing and handling these should be updated to reflect this. Any collection or offsite use would require the hazardous nature of these materials to be declared through a SDS and waste manifest document.

Tar legacy:

Clarity should be provided on whether DMPT has any liability in terms of this waste. If not, it should be removed from this document.

The placement of historic tar waste, presumably hazardous, in unmanaged 'consolidation sites' that have no form of source prevention or pathway protection is not ideal and should be reconsidered. Cognisance should be given to the South African National Norms and Standards for Waste Storage in this regard.

Arsenic cages and bags:

It should be specified that these are hazardous wastes and need to be appropriately managed.

Storage of the bags and cages needs to be in bunded areas or under roof. The procedure for storing and handling these should be updated to reflect this.

Restrictions should be placed on where and how these cages are cleaned as the wash bay is presumably not designed to manage hazardous material residues.

If disposed to the hazardous waste site then reference the Hazardous Waste Disposal Site Operations Manual.

Construction and Project Wastes:

Suggest to change "identified in this document will be disposed of as indicated" to "identified in this document will be *managed* as indicated".

Storage of any hazardous wastes must be in bunded areas or under roof.

Garden and Food wastes:

It is suggested to insert a section for the management of garden and food wastes.

The management of these wastes should advocate for the separation of these wastes from the general domestic waste stream for use in composting (understood to be planned).

ID of bins and skips:

Suggest moving this text to the Systems and Infrastructure section of this Procedure.

Waste Removal Intervals:

Suggest moving this text to the Systems and Infrastructure section of this Procedure.

2.7 DATA MANAGEMENT

Data management with respect to waste should be undertaken in terms of the relevant regulations and norms and standards. There are specific requirements for the keeping of waste manifest documents for all hazardous wastes that are generated and which depart the DPMT site. The Waste Management Procedure should be updated to reflect these requirements.

2.8 ASSOCIATED DOCUMENTS

The Hazardous Waste Disposal Site Operations Manual (DPMT, 2016) should be referenced, as should all other procedures that relate to waste management. Reference should also be made to the Hydrocarbon Spillage Response (DPMT, 2013)

3 REVIEW OF THE HAZARDOUS WASTE LANDFILL SITE

SLR conducted a site visit to the Tsumeb Smelter on 6 July 2016 in order to assist in assessing the operation, and potential future suitability, of the hazardous waste disposal site (HWDS). Several studies have been performed and reports generated for the HWDS, with the following being specifically reviewed by SLR:

- "Dolomite Stability Assessment for Phase 3 of the Hazardous Waste Facility at Tsumeb Smelter, Namibia" by GCS Geotechnical dated 5th May 2016 (Report Ref: 15-0871.02R01);
- Engineering for the Future Development and Extension of the Hazardous Waste Disposal Site" by Golder Associates dated September 2015 (Report Ref: 1411226-13839-1);
- "Closure Design for the Hazardous Waste Disposal Facility at DPM Tsumeb" by Golder Associates dated November 2013 (Report Ref: 12614861)

3.1 DOLOMITE ASSESSMENT

Further to the site inspection, SLR reviewed the dolomitic stability assessment report for the expansion of the existing HWDS by GCS Geotechnical (Ref: 15-0871.02R01). The stability assessment was undertaken as the site is underlain by dolomites which are susceptible to dissolution in the presence of acids and subsequent collapsing of overlying soils into the cavities formed. On the basis of the information presented in this report, it is considered that should the recommendations be adhered to, there would be very a low risk of dolomitic instability. The area is already inherently *low risk* for all-sized sinkholes and dolines, having a hazard class 1/1 and subsequent management designation of the area as D3. According to the SANS 1936-1:2012 regulations, this recommends that "Precautionary measures in addition to those pertaining to the prevention of concentrated ingress of water into the ground are required to support the development in accordance with the relevant requirements of SANS 1936-3" be taken. By implementing measures, such as lining the facility, coupled with consistent monitoring of the excavations, the expansion of the HWDS would not pose a significant risk with respect to dolomitic stability. Due to the acidic nature of the leachate water at the HWDS that may come into contact with the underlying dolomite, as well as potential infiltration of acidic water from the rest of the smelter site that could lead to dolomitic dissolution, surface water management is of particular importance. Critically important too is the installation of a robust lining system, as leachate leaking through the containment could not only cause environmental contamination, but also potentially jeopardise the stability of the site

due to the formation of voids through dissolution of the underlying dolomite and subsequent subsidence of the overlying ground into these voids.

3.2 LINER ASSESSMENT

The lining system to the HWDS at Tsumeb comprises the following layers (working from the top downwards):

- 300 mm calcrete neutralisation layer;
- 300 mm slag leachate drainage layer;
- 2 mm high density polyethylene (HDPE) geomembrane (primary composite liner);
- 300 mm compacted clay liner (primary composite liner);
- Woven geotextile separator
- 150 mm stone leakage detection layer; and
- 300 mm compacted clay (secondary liner).

An assessment of the lining system was previously undertaken by SLR (Report No. 1 SLR, 2014) which noted that the current lining system did not meet minimum requirements set out in the South African Department of Water Affairs (DWAF) Minimum Requirements as illustrated in **Error! Reference source not found.**.

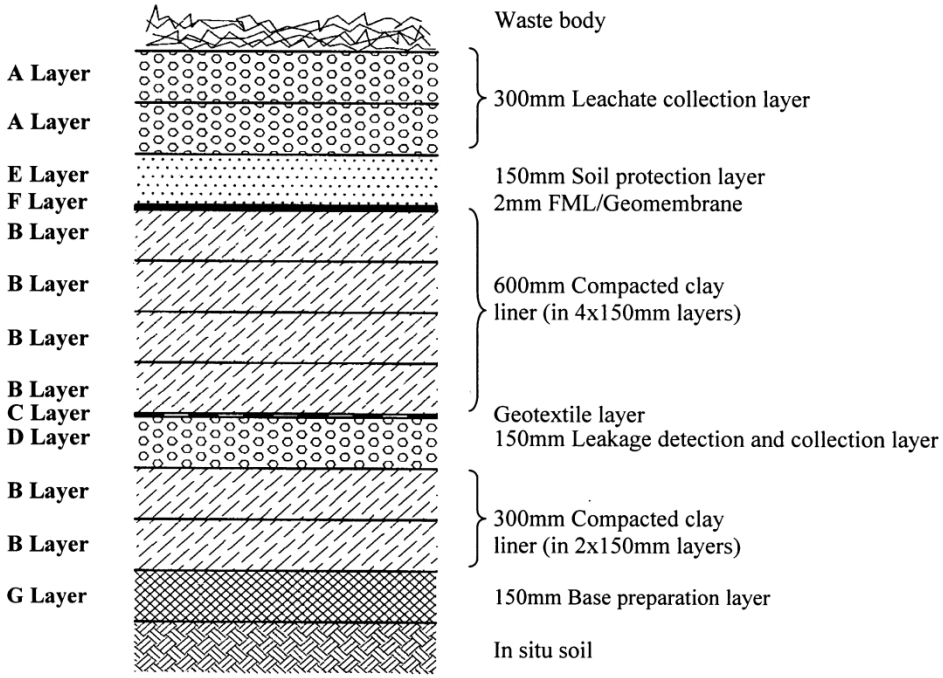

FIGURE 3-1: HAZARDOUS LANDFILL LINER REQUIREMENTS (SA-DWAF, 1998)

Environmental monitoring undertaken on site however indicates that the HWDS lining system provides adequate protection to groundwater, since:

- Ground water monitoring data provided does not indicate that there has been any direct contamination of the groundwater resulting from leakages through the lining system; and
- No leachate has been detected in the leachate detection layer.

It is understood that a cell immediately west of the existing cell and leachate collection pond, with the same lining system as the existing cell, has been permitted for construction. We would however recommend that any future expansion be lined in accordance with best practice i.e. South African General Norms and standards for disposal of waste to landfills (GN R636). This recommendation is supported by Golder and Associates (2013) in their Closure Design report and could also lead to a less onerous capping layer being required upon closure.

3.3 CAPPING AND CLOSURE

A comprehensive closure design and management plan has been compiled by Golder and Associates in which they propose to cap the existing HWDS with a cap design illustrated in Figure 3-2.

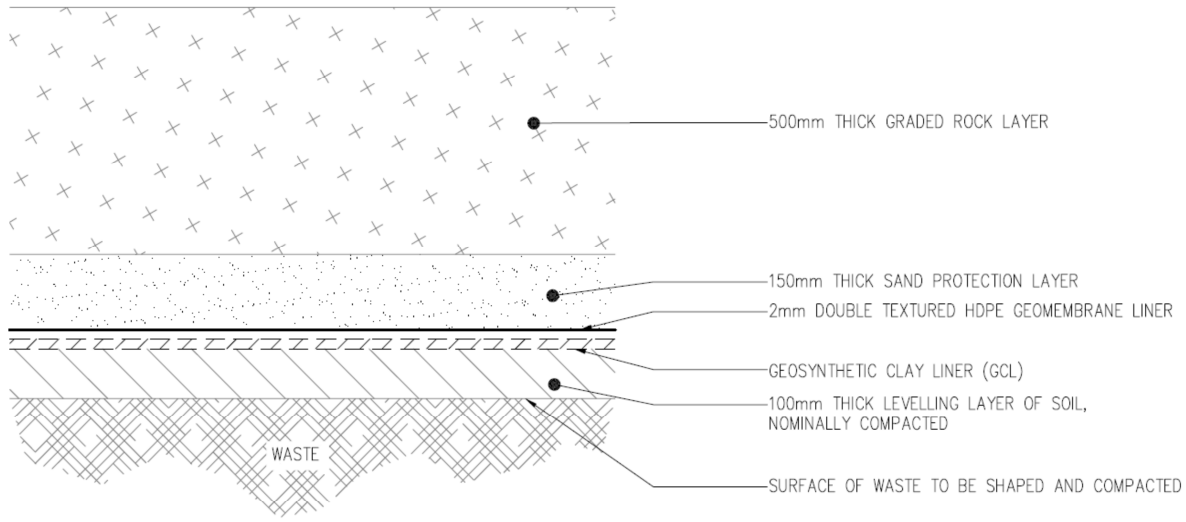

FIGURE 3-2: HWDS CAPPING DESIGN (GOLDER ASSOCIATES, 2013)

Although the above capping layer is comprehensive and adheres to current South African standards (GN R636), it is recommended that it quantifiably be illustrated that the current slightly lower specification liner, combined with the capping proposed, would result in equal or less pollution to the environment than the implementation of a liner/capping system that is as per the those stipulated in GN R636.

3.4 CAPACITY REVIEW

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 approx. 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 has 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 m^3 (Golder, 2015)
- Airspace of entire permitted landfill area = 153 047 m^3 (Golder, 2015)
- Volume deposited up to and including June 2016 = 8 242 m^3 (DPMT records and using density of 2 tons/m^3)
- Airspace available as at July 2016 = 47 480 – 8 242 = 39 238 m^3
- Life of existing cell = 39 238/999 m^3/month (DPMT) = **3.3 years**
- Life of entire permitted landfill area = (153 047 – 8 242)/999
  = **12.1 years**

Based on future waste volumes with expansion of the facility

The 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 is a circa 55% increase, commencing at the end of February 2017. 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 has not been considered. DPMT also plan on ceasing the operation of their 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 to the HWDS.

Existing Cell:

- Airspace as of July 2016 = 39 238m^3
- Input July 2016 to Feb 2017 = 999m^3/month x 7 months = 6 993m^3
- Remaining Airspace as of February 2017 = 32 245m^3
- Input after Feb 2017 = 999m^3/month x 80% = 1 798m^3/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 = 144 805m^3
- Input July 2016 to Feb 2017 = 999m^3/month x 7 months = 6 993m^3
- Remaining Airspace as of February 2017 = 137 812m^3
- Input after Feb 2017 = 999m^3/month x 80% = 1 798m^3/month
- Life of Entire Permitted Landfill = 7 months + (137 812 / 1 798) = 77 months (or 6 years and 5 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 HWDS. This is based on the assumption that all arsenic waste would be disposed of at the HWDS and that no other options for disposal are considered.

3.5 OPERATIONAL REVIEW

Further to the site visit conducted, SLR also reviewed DPMT's Hazardous Waste Disposal Site Operations Manual (DPMT, 2016) in order to determine any potential shortfalls in the operations and identification of any improvements that could be implemented.

The operations manual is comprehensive and SLR is happy that the procedures currently employed at the site adequately prevent the excessive generation of dust which could affect the surrounding environment. The collection and reuse of water also appears to indicate that no environmental contamination has or is likely to occur as a result of leachate from the HWDS.

Although there is no evidence to suggest that the HWDS is itself specifically causing unacceptable environmental degradation, a more focussed monitoring programme for the HWDS is required to confirm this, as opposed to the general site-wide monitoring programme currently being undertaken. This view is further supported by the external audit of the HWDS conducted by Resource Management Services in their external compliance audit report (Report No: RMS/DPM/AUDIT/11/15, November 2015) in which they state:

"The External Compliance Audit Report is not conclusive in confirming that the current site has definitely no impact on the receiving environment. It can be stated with some confidence, however, that the probability of the site being a significant point source of pollution (air and groundwater) with the acceptance that the proposed site operational manual requirements are fully complied with, is low."

Results from the currently conducted air and groundwater monitoring will offer some further confirmation of the above and should be reviewed in conjunction with this report. In order to gain further confidence in these assertions; it is recommended that additional monitoring boreholes located closer to the actual HWDS be installed for more accurate identification of any direct groundwater contamination by the HWDS.

3.5.1 RECOMMENDATIONS

Although the current landfill operations and management do seem to be adequate, SLR suggests the following additional steps to be taken to further improve the efficiency of dust suppression, with little additional cost:

- The use of tarpaulins to act as a temporary cover, placed over the areas of the HWDS not being used/deposited to;
- The addition of a chemical dust suppression agent to the water currently used for dust suppression – this will increase the efficacy of dust suppression, and thereby decrease the amount of water required, by approximately 100% (e.g. 88Chemco product)

3.6 REVIEW OF ALTERNATIVES

If the Namibian Environmental authorities do not give final consent to DPMT to develop Phase 2 of the HWDS, as has originally been granted, DPMT will be forced to pursue other, less desirable, waste disposal options. The other potential options are disposal to a mooted regional site in Namibia which would still need to be constructed or to transport the wastes to hazardous waste sites within neighbouring South Africa. DPMT are also actively 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.

3.6.1 DISPOSAL TO REGIONAL NAMIBIAN HAZARDOUS LANDFILL SITE

At this stage it is still unclear whether this would be developed, which in itself poses an operational risk to DPMT. If no alternative is developed (e.g. expansion of the current HWDS) in expectation of the regional landfill being considered, DPMT would conceivably risk having to cease operations. This would be unacceptable from DPMT's commercial perspective but also from a local economic perspective for the town of Tsumeb.

3.6.2 DISPOSAL TO SOUTH AFRICAN HAZARDOUS LANDFILL SITE

There are several, suitably designed and constructed hazardous landfill sites in South Africa which waste could be transported to. DPMT is already in advanced negotiations with such a facility for transporting a test volume of 360 tons of waste per annum. Such a disposal route would have significant cost implications associated with it, as well as potential environmental risks associated with transporting hazardous substances long distances by road. If it chooses to pursue this option, DPMT intends to do so according to the requirements of the Basel Convention, South African and Namibian legislations for hazardous waste transportation.

3.6.3 VITRIFICATION

Vitrification entails the heating of flue dusts at high temperatures, eventually resulting in conversion of the dust to inert glass. This process is currently being investigated by DPMT with promising initial results. It is currently predicted that there is a potential market for the sale of 4 000 tons/annum of the glass product.

3.7 RECOMMENDATION

Given the uncertainties, costs and risks associated with the alternative options set out above, SLR is of the opinion that the expansion of the HWDS would be the most appropriate medium to long term option and should be pursued as a matter of urgency. Initially the western portion of the permitted area should be developed, using a lining system which is in accordance with internationally accepted best practice, for example the South African General Norms and standards for disposal of waste to landfills (GN R636). Once the cell in the western portion of the permitted area has been constructed, the existing eastern portion should be capped and closed as soon as the final waste levels have been achieved. The currently permitted site is estimated to give DPMT less than 6.5 years of further operational life, assuming an increase in waste production of 80%. This life span could be increased if there is a decrease in waste generation due to either increased operational efficiencies or growth in the market appetite for the vitrification of the flue dust. If hazardous waste generation is not significantly reduced and no regional facility is to be developed, DPMT should investigate further extension of the HWDS.

SLR consider that the HWDS operational manual and procedures are adequate, but would 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.

4 ASSESSMENT OF CURRENT WASTE MANAGEMENT PRACTICES

SLR conducted a site visit to the Tsumeb Smelter on 9 June 2016 in order to view and assess the waste management operations at the Tsumeb facility. Not every site within the facility was inspected, but the key waste management facilities were viewed and discussions held with persons in the Environmental Department. Aspects relating to the hazardous waste site are reviewed in Section 3 and not discussed further here. Aspects relating to the Tailings Dams are discussed in Section 7. Key comments are as follows:

Scrap yard:

The scrap yard includes contains a wide variety of accumulated materials. In general convention the distinction between scrap materials and waste can be vague, and in some cases overlapping with scrap being considered as waste until it is recycled, recovered or reused. It is assumed that the scrap yard managers have measures in place to prevent the accumulation of waste at the scrap yard although the Scrap Management Procedure (5_P_1.03) has no clear method to differentiate or separate scrap from waste. Neither is there any indication of how the scrap yard manager returns wastes into the waste management system, should materials cease to be scrap.

Discarded transformers were noted in the scrap yard at the Tsumeb Smelter. It was unclear as to whether these transformers had been drained of oils. It is recommended that a procedure be put in place to ensure that any scrap is appropriately decontaminated before going to the scrap yard. The decontamination must be done in a method and location that provides for the protection of the environment, such that any wastes arising are appropriately managed.

Building rubble stockpiles:

A variety of building rubble and demolition waste heaps were observed. It is understood that some of these existed prior to DPMT's tenure at the Tsumeb Smelter. In order for the storage of building rubble and demolition waste at unprotected sites to be without significant risk, such wastes should be inert, but it was evident that significant hazardous and other general wastes were included with these building rubble heaps. Refractory bricks, gas canisters, hydrocarbon drums and paint tins were observed, amongst others. These hazardous materials are likely to have been or be resulting in environmental pollution and health and safety risks.

Various scrap and or recyclable materials were also observed. It is suggested that a process should be put in place to review the content of the existing building rubble heaps to identify hazardous waste components. Those components that continue to result in risk to the environment should be removed for appropriate storage or disposal. Any personnel or contractor involved in reworking these wastes should be advised of the risks of the hazardous components.

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:

Only a few contractor yards at the Tsumeb Smelter were inspected. At these there was evidence of inadequate waste management practices. A notable example was the storage of waste oil and sludges from the clean-out of a workshop sump in damaged 210 l drums (see Plate), placed directly on the ground and in the open. A second example was dirty transformer oils recovered during servicing of an electrical sub-station standing on a pallet adjacent to a storm water drain. Such practices are likely to have been or be resulting in environmental pollution.

It is recommend that contractors be advised the on DPMT Waste Management Procedure and contractually obliged to comply with the requirements thereof.

Plate: Uncovered and damaged drums with waste oil and sludges stored in an unbunded area

Bins and skips around facilities:

It was evident that there was little consistency in the allocation of bins and skips to different sites and that different colour bins and skips were used interchangeably and not in line with the Waste Management Procedure. There was little evidence of labelling on waste containers or at the various waste collection sites. While some recycling stations were observed, there was no further evidence of any general waste recycling practices. A consistent approach to the use of coloured and labelled containers should be implemented.

At most of the visited sites the bins and skips for hazardous waste were not located in bunded areas. It is recommend that hazardous waste containers are only placed in bunded areas, and preferably under roof or such containers should have lids.

General waste handling area:

The current general waste handling area is a significant cause of concern and its operation is likely to be resulting in impacts to the environment as well as occupational health risks. Other than being fenced, the site has no facilities to enable the appropriate management of general waste (also see Section 4.1).

The site is considered by DPMT as a 'general waste site' and yet there was evidence of various hazardous wastes within the waste stream, as well as active management of these hazardous waste streams (separation of Tyvek suits and other materials). See Plate. 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. It is recommended that the source practices which are resulting in hazardous wastes being included in the general waste stream be altered immediately. 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.

Plate: Hazardous waste management at the 'general waste handling area' at Tsumeb Smelter

The second concern is that the general waste handling area is being operated for the:

- storage of unsorted wastes;
- for the undertaking of sorting;
- for the storage of sorted wastes;
- for waste burning, and
- for the disposal of ash from the burning of waste.

This combination of activities at a site with no facilities, and which is subject to limited management, is considered the incorrect approach. The general waste handling area does not have any waste management facilities and none of the site aspects or its operations are in line with best practice for waste management. The latter two practices in particular are inadequate and would be considered unlawful in Namibian and South African law, unless specifically licensed. Management and operations of this general waste handling area need to be revised as a soon as possible and a waste disposal solution added.

It is recommended that the practices which are resulting in unsorted general waste arriving at the general waste handling area be altered as soon as possible. Recyclable materials should be collected and stored at one location for further sorting and or processing. This would 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. The ash has the potential to be hazardous and it is recommended that it should be disposed to the Hazardous Waste Site.

It is understood that 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). Although the current site has been used for over 20 years, it has no EMP and has not been audited. As an international company, it would neither be appropriate nor acceptable from an environmental or social point of view for DPMT to dispose of waste at that facility. Thus the current municipal general waste disposal site is not a viable alternative for the disposal of general waste from the DPMT site. The alternatives for DPMT to facilitate the responsible disposal of general waste from the site would be the establishment of the approved general waste disposal site at the Tsumeb Smelter or the installation of a small incinerator to manage the residual, general waste stream. It is understood that DMPT had previously elected to establish a general waste disposal site at Tsumeb Smelter. See Section 4.1 in this regard. Also refer to the cost-benefit-analysis of a general waste disposal site versus a small incinerator in Section 9.

Legacy wastes (slags and arsenic calcine):
Refer to Section 7.

Sewage plant:
It is understood that the sewage plant is relatively new and therefore anticipated to be adequate to manage the sewage requirements of the DPMT. The plant was however not operational at the time of the site visit due to hydrocarbons entering the sewage system and potentially damaging the infrastructure. Thus untreated effluent was being pumped to a lagoon/reed bed near the calcine dump. Residual sludges are to be dried on evaporation pads.

The source of the hydrocarbons in the sewage is subject to an investigation. The sewage plant should be restored to operation as soon as is possible. The untreated effluent is likely to be a health and safety risk and the area should be adequately signed and possibly fenced. There are also risks of surface and

groundwater contamination from the faecal content as well as from heavy metals. Monitoring is recommended.

Tar pits:

Evidence exists of a number of historical tar disposal pits on the site. It is understood (JAWS 2011) that some of these have been consolidated to a single location but a number of separate sites still exist. These sites effectively constitute storage of the wastes, however the sites have no facilities or management and the current methods of storage of the tars does not comply with the National Norms and Standards for the Storage of Wastes (GN R 926 of November 2013).

It is unclear whether these tars have contributed at all to groundwater contamination. A study by Jones and Wagener (Synergistics Environmental Services. December, 2009, Preliminary Assessment of the Contamination Risks to the Groundwater regime at the Tsumeb Smelter, Report No.: JW181/09/C391, Revision 2) suggests that these deposits (or at least the consolidated site (tar pit)) are unlikely to cause hydrocarbon pollution. SLR note that GCS (15-642 of April 2016) recommended to DPMT the implementation of a monitoring program for hydrocarbons in groundwater.

Projects yard:

A number of wastes or redundant/damaged materials and containers were noted, including a number of drums of hazardous materials as well as powders in paper bags (disintegrating). 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. The result is that the exposed wastes are likely to be contributing to a reduction in the quality of storm water and any resulting runoff could be compromising the quality of surface water in the surrounding environment (and or groundwater). In addition the sediments derived from the waste management facilities are likely to be contributing to blockages of the drainage systems. It is understood that DPMT have however conducted an assessment for the remediation of this, via the report by Aurecon (Ref. 109185, 2014) which without having interrogated in appreciable detail due to it being outside the scope of this study, SLR are fundamentally in agreement with. However it is likely that additional/specific work may be required in order to contain contaminated surface water runoff arising from the waste management facilities at the Tsumeb Smelter.

4.1 GENERAL WASTE LANDFILL SITE

As detailed in the Synergistics Environmental Services' document (Ref N0664/REP04, January 2013), DPMT had applied to and obtained environmental clearance from the MET (dated 9 August 2013) for the establishment of a General Waste Landfill Site at the Tsumeb Smelter. The environmental clearance was valid for a period of 3 years and has now expired.

It is evident to SLR from the review of the General Waste Landfill Site documentation and the June 2016 site visit, that the current general waste handling area is not in any way, shape or form the General Waste Landfill Site that was designed, assessed and approved by the MET. Personnel at the smelter have indicated that location proposed for the approved General Waste Landfill Site was taken over by the lay-down area for the construction of the Sulphuric Acid Plant and with the site unavailable, the facility was never developed.

Although DPMT had obtained approval for a General Waste Landfill Site, this was never formally developed due to the establishment of the sulphuric acid plant being prioritised at the time. As part of the current EIA process for the Smelter Optimization and Upgrade Project it is proposed to cover the development of the General Waste Landfill Site under the Amended ECC.

Due to the General Waste Landfill Site not being established, the current general waste management operations at the Tsumeb Smelter are likely to be resulting in human health risk as well as contributing to environmental pollution (see previous discussion in Section 4 in this regard). Although in the cumulative context of the Tsumeb Smelter it is likely that many of these impacts would 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 General Waste Landfill Site is constructed, or measures are implemented to enable sanitary general waste management at the Tsumeb Smelter.

It is recommended that the renewal of the environmental clearance from the MET be secured and the development of the General Waste Landfill Site be undertaken as soon as possible. This should be viewed as urgent by DPMT. It is recommended that all details from the EMP submitted for the General Waste Landfill Site be included in the current EIA and EMP for the Smelter Optimization and Upgrade Project.

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 arisings at the Tsumeb Smelter. Refer to Section 9 for a high-level cost benefit analysis between a General Waste Landfill Site and a general waste incinerator.

5 LABORATORY WASTE MANAGEMENT PRACTICES

It is understood that the 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

6 REVIEW OF RECYCLING PRACTICES

SLR observed that very limited recycling is undertaken at the DPMT. Other than the active recycling of scrap metal, SLR did not observe any meaningful recycling practices at the DPMT (although it is understood that printer cartridges are recycled). Despite the presence of recycling stations at some of the facilities, it was evident from observations at the general waste handling area that paper, cardboard, plastic, polystyrene, wood, cans and glass are currently burnt rather than being recycled. This is not in line with best practice, nor applicable local legislation.

It is understood from discussions with personnel in the Environmental Department that recycling practices in the Tsumeb region are not economically viable due to the long transport distances. Apparently various recycling businesses have tried and failed in Tsumeb. Thus while DPMT generates wastes that are recyclable (and in reasonable volumes) prevailing market economics may prevent recycling from being a viable consideration. In light of this it is considered unlikely that re-use and recycling will be a viable alternative for any significant component of the waste stream at the DPMT at this point in time. However, it is possible that new recycling industries are established in the future and

therefore, the DPMT should continue to be open to and investigate any opportunities. DPMT should be aware that not recycling is likely to result in direct and indirect environmental impacts and may result in non-compliance with the regulatory framework (such as disposal restrictions).

Re-use, recycling and recovery are key components of any waste management strategy and an essential tool in the implementation of the waste management hierarchy at any facility. It is suggested that the DPMT consider implementing a Corporate Social Initiative project in order to enable the establishment of one or more initiatives for the re-use or 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.

The following (assuming there commercially viable options available) are suggested for a recycling programme at the DPMT.

Waste Reduction and Minimisation:

Waste prevention or minimisation is arguably the most effective means of managing waste. These measures focus on reducing or eliminating the generation of waste at the source, which is in contrast to the balance of the waste management hierarchy that focuses on processing waste after it is created. Minimisation is the process of reducing the amount of waste produced by a person or an activity. This typically requires efforts to minimize resource and energy use during production so that, for the same output, fewer materials are used and less waste is produced. Potentially available techniques for consideration include:

- Education and awareness;
- Efficiency and resource optimisation;
- Improved quality control and process monitoring; and
- Extended producer responsibility.

The education and awareness training and induction, with respect to waste management, should inform and guide personnel on opportunities for waste minimisation. The department responsible for procurement at DPMT can influence waste production by facilitating resource optimisation. Ordering schedules should be optimised with consumption profiles to limit wastage. This is of particular relevance with products that expire.

Procurement should also aim to order from local suppliers or to specify the minimum packing requirements in order to reduce the volume of packing waste. Products should be purchased in bulk where feasible rather than in smaller lots which have a relatively higher packing component.

Lastly the Procurement department should aim to invoke extended producer responsibility with suppliers whenever possible. This is particularly appropriate for products that are delivered in re-useable containers or packing. In this case the supply contract should include the removal of empty.

Re-use and Recycling:

Re-use is the utilisation of articles from the waste stream for the same or different purpose without changing the form or properties of the article. Recycling is the process where waste is reclaimed for further use by separation of the articles from the waste stream and the processing of the separated material to create a new product or raw material. It is noted that the legislation sets out that re-use, recycling or recovery of waste must:

(a) use less natural resources than disposal of such waste; and
(b) to the extent that it is possible, is less harmful to the environment than the disposal of such waste.

Items that are typically considered for re-use and recycling include scrap metal, glass, paper and cardboard, plastic and organic materials. Items requiring greater technology to recycle include printer cartridges, electronic wastes, fluorescent tubes, batteries, used mineral oil and tyres.

The recycling of each of these waste streams can be facilitated though source separation, collection and storage of the appropriate materials. The wastes can be made available to 3rd parties who facilitate or specialise in the re-use or recycling of particular waste streams. Prior to any re-use or recycling of waste, it is essential that DPMT ensure that the waste is appropriately recorded, is *fit-for-purpose* and safe for the proposed use. DPMT, as the waste generator, also has an obligation to ensure that any waste recyclers operate in manner that does not pose significant risks to human health or the environment. Residual waste produced by the recyclers must be appropriately managed.

7 IMPACTS OF HISTORIC WASTES

The historic or legacy wastes stockpiled or disposed around the DPMT site are understood to comprise mostly slags (from the furnaces and convertors) and arsenic calcines and dusts. These have been generated over decades of operation at the Smelter and are widely distributed across the site. None of the legacy wastes (other than ~ 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, or continue to be, resulted in environmental pollution and degradation. It is understood by SLR that, in terms of an agreement with the MET, DMPT is not responsible or liable for impacts caused by many of the historic or legacy wastes. DPMT has however committed to managing all arsenic related concerns at the Tsumeb Smelter.

The exact chemistry of each legacy waste stockpile is not known to SLR but it is understood that the composition of each could vary considerably (both between and within stockpiles) depending on the source materials and the processing undertaken at the time of production. 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 Minimum Requirements series (DWAF, 1998). In general Jones and Wagener found that the slags would pose a relatively low risk to groundwater, due largely to the low mobility of chemicals of concern. The baghouse dust and calcines were however noted to pose a significant risk to soils and groundwater and the removal of these materials to the Hazardous Waste Disposal Site was recommended. It is understood that the disposal of these arsenic calcines to the HWDS was documented as a commitment in the EMP approved by the MET.

To SLR's knowledge the disposal of the legacy baghouse dust and calcines stockpiles to 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 failure to dispose of the arsenic calcine legacy wastes to the HWDS is a non-compliance with the EMP and is continuing to contribute to the reduced groundwater quality. DPMT is advised that the current method of storage of the legacy wastes does not comply with the National Norms and Standards for the Storage of Wastes. It is recommended that these wastes should at least be stored or managed in an improved manner (to limit infiltration into and through the waste body) and preferably be disposed to the hazardous waste disposal site as soon as is possible (subject to the airspace capacity constraints being resolved). There may then be a need to undertake a contamination assessment of the soils underlying the cleared footprints.

It is known that here is no longer airspace available in the current phase of the HWDS to receive all of the legacy baghouse dust and calcines stockpiles at the Tsumeb Smelter requiring disposal, thus an alternative solution is required. See Section 3.6 for a discussion of alternative solutions for the management of hazardous wastes from Tsumeb Smelter. DPMT is advised that a solution (s) chosen to meet hazardous waste management requirements at the Tsumeb Smelter should allow for the management of the legacy wastes for which DPMT is responsible.

DPMT is further advised that although the legacy wastes have previously been subject to classification under the Minimum Requirement (by JAWS in 2011), the WCMR requires classification in terms of SANS 10234 (using the Globally Harmonized System of classification and labelling of chemicals (GHS)) within 3 years from August 2013, and every 5 years or within 30 days of modification to the process or activity that generated the waste, changes in raw materials or other inputs, or any other variation of relevant factors.

8 TAILINGS FACILITY REVIEW

The existing tailings dam facility was visited by SLR on the 6th July 2016, as well as previous reports reviewed, and although a comprehensive assessment was not specifically conducted, no issues were identified which DPMT were not already aware of. These include:

- the major erosion that has taken place on the side walls of the dam,
- contamination of the soil and groundwater immediately beneath the tailings dam that has taken place due to the facility not being lined, evidenced by the GCS DPMT Tailings Leachate and Tsumeb Smelter Groundwater Model Update Reports (GCS, 2016).

8.1 CLOSURE

Only a relatively small portion of the tailings dam is currently being used and it would be preferable that the area which is not being used for tailings deposition be suitably capped and rehabilitated; this is especially relevant in this instance as the facility is not lined. It is recommended that the South African Department of Water Affairs (DWAF) minimum requirements are used as guidance, which state that "When comparing the capping designs with the corresponding liner design, it must be realised that the cap works in conjunction with the liner by limiting the long term generation of leachate" (1998). SLR therefore find it imperative, if DPMT wish to be in line with local and international best practice, to suitably cap that portion of the facility which is no longer being used in order to limit water ingress into, and dust production from, the tailings dam. Golder and Associate's Closure Plan Report of November 2013 (Report No. 13614914 – 12263 - 1) details the measures that should be taken in order to effectively close the facility.

8.1.1 DPMT CLOSURE PROPOSAL

DPMT have already begun investigating the options for adequate closure of the unused tailings facilities and propose to undertake phytoremediation to achieve this as quoted below:

"Polluted land (soil, water, tailings and wastes) and tailings dams will be rehabilitated by means of phytoremediation strategies where appropriate. Plants will be propagated in the on site nursery and site-specific biological technologies will be identified for the decontamination and "making-safe" of polluted soils and water, and in situ phytostabilisation of tailings and wastes, alongside protective socio·ecological and sustainable development strategies in the area. This is to be accomplished via integration and desk-

top review of all existing written and spatial (GIS and other) information, surveys on-site of plants and socio-ecological aspects, trials on site with plants and microorganisms, and modelling and costing of the "decontamination" or "phytostabilisation" that is feasible based on the results of the trials and the results of the Soil Survey, the Contaminated Land Assessment and other studies that have been conducted at DPMT (e.g. hydrological modelling and geotechnical surveys). These technologies include, but are not limited to:

(a) hydrological control of polluted groundwater using trees,

(b) polishing of effluents using riparian or wetland systems,

(c) the removal of salts and metal/loids from polluted substrata (soil and water) by salt and metal/loid accumulating indigenous plants (halophytes and metallophytes), and conversely (d) the in situ stabilization of metals (by non-accumulating or excluding plants) on tailings facilities and hazardous wastes – in particular using those metal- and salt-tolerant plants identified on Site, of which some are already in use by mining companies in South Africa" (I. Weiersbye, 2014).

8.2 CONCLUSION

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. 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.

It must be reiterated that SLR did not perform a formal, comprehensive assessment of the tailings dam but only a brief, cursory site visit in order to support the overall waste management review. The above high level review and recommendations should therefore only be viewed in context and not relied upon for any decision making purposes.

9 COST COMPARISON

This section of the report aims, from a high level perspective, to illustrate the least cost option for disposal of general waste at the Tsumeb smelter between the two options being considered, namely incineration and landfilling.

9.1 ASSUMPTIONS

- A 24 year time horizon has been used for each facility to compare life time costs as this was the original life estimation for the designed landfill site.
- No energy will be recovered from the incineration facility - this both reduces the initial capital cost and the energy generation/revenue figures for the incinerator.

- In keeping in line with international best practice, emissions from the incinerator will be controlled and therefore the type of incinerator investigated will have flue gas cleaning capabilities and will be operated in such a way so as to ensure emissions are controlled.
- No labour costs have been included in the analysis as it is assumed that the same amount of labour will be used for both of the landfilling and incinerator operations.
- Future values have been discounted at a rate of 10%, and increased for inflation at a rate of 6% resulting in a net future value discount rate of 4% (this can be changed in the model to be in line with DPMT's borrowing costs and inflations estimations).
- As the landfill will be on site, no gate fees have been used in the calculation. Similarly, the disposal of the flue dust from the incinerator to the existing HWDS has also not been costed as this would be done by DPMT themselves and would contribute only a small amount to the total volumes already being disposed of.
- The current disposal volume requirement of 5m^3/day will not vary throughout the 24 year time frame assessed.
- Waste density <500kg/m^3.

9.2 LANDFILL INPUTS TO FINANCIAL MODEL

- The cost to construct the landfill site will be based on the design that had previously been done for DPMT and subsequently submitted to, and accepted by, the Namibian authorities by Hill and Associates (April, 2012). This total cost (CAPEX) for all 3 phases amounts to N$1 911 220 (2016 Namibian Dollars) and will be constructed in phases every 8 years
- A nominal value of N$75 000/annum has been assumed for the day to day operation (OPEX) of the landfill site.
- A value of N$2 000 000 has been estimated for the complete capping and rehabilitation of the landfill upon closure to be in line with international best practice (SLR Consulting, 2016).

9.3 INCINERATOR INPUTS TO FINANCIAL MODEL SCENARIOS

As pure incineration, without the recovery of heat/energy, is not common practice and in certain parts of the world (United Kingdom & Europe) outlawed, it is difficult to find up to date data on the subject. What was apparent from the review of various studies (Department of Environment Food & Rural affairs, 2013 and Collins & Donovan, 2011) was that incineration is generally appreciably more expensive than landfilling. Due to the uncertainties and large number of variables at play, several scenarios were considered for the financial model listed below in order of desirability from an environmental and permitting perspective:

1. Cost-effective incinerator with nominal gas cleaning and fuel usage to ensure complete combustion;

2. Cost-effective incinerator with nominal gas cleaning and zero fuel usage;
3. Cost-effective incinerator with no gas cleaning or fuel usage.

From literature reviews and supplier research, the following costs were used in the models (if applicable to the relevant scenario):

- Incinerator capital expenditure (CAPEX) - N$950 000 (Excluding excise duties). This is from a reputable South African company and with capabilities to cater for DPMT's requirements (Saubatech, 2016).
- Rudimentary flue gas cleaning/scrubbing – N$5 650 000
- Incinerator annual operating costs (OPEX) – N$24 000 (Saubatech, 2016).
- Incinerator major maintenance estimated to be needed once every 8 years – N$80 000 (Saubatech, 2016).

9.4 LIFETIME COST COMPARISON

The results of the financial modelling are presented in **Error! Reference source not found.** below. Due to space constraints, only every 8 years of the project lives are illustrated. The financial model and its outputs have been forwarded to the client as an appendix in the form of an electronic spreadsheet.

TABLE 9-1: COST COMPARISON BETWEEN INCINERATOR AND LANDFILL FOR SELECTED YEARS OF LIFE AND SCENARIOS

Scenario 1								
	Year 0		Year 8		Year 16		Year 24	
	Landfill	Incineration	Landfill	Incineration	Landfill	Incineration	Landfill	Incineration
Capex:	$ 910 610.02	$ 6 500 000.00	$ 332 686.91		$ 243 091.07			
Fuel:				$ 576 076.16		$ 420 933.21		$ 307 571.77
Maintenance:						$ 3 250 000.00		
Opex:			$ 54 801.77	$ 17 536.56	$ 40 043.11	$ 12 813.80	$ 29 259.11	$ 9 362.92
Rehabilitation:							$ 780 242.95	
Cumulative NPV:	$ 910 610.02	$ 6 500 000.00	$ 1 748 252.80	$ 11 969 681.94	$ 2 360 310.18	$ 19 270 370.09	**$ 3 410 153.19**	**$ 22 190 677.99**

Scenario 2								
	Year 0		Year 8		Year 16		Year 24	
	Landfill	Incineration	Landfill	Incineration	Landfill	Incineration	Landfill	Incineration
Capex:	$ 910 610.02	$ 6 500 000.00	$ 332 686.91		$ 243 091.07			
Fuel:				$ -		$ -		$ -
Maintenance:				$ 58 455.22		$ 42 712.65		
Opex:			$ 54 801.77	$ 17 536.56	$ 40 043.11	$ 12 813.80	$ 29 259.11	$ 9 362.92
Rehabilitation:							$ 780 242.95	
Cumulative:	$ 910 610.02	$ 6 500 000.00	$ 1 748 252.80	$ 6 720 041.09	$ 2 360 310.18	$ 6 880 822.97	**$ 3 410 153.19**	**$ 6 967 094.99**

Scenario 3								
	Year 0		Year 8		Year 16		Year 24	
	Landfill	Incineration	Landfill	Incineration	Landfill	Incineration	Landfill	Incineration
Capex:	$ 910 610.02	$ 950 000.00	$ 332 686.91		$ 243 091.07			
Fuel:				$ -		$ -		$ -
Maintenance:				$ 58 455.22		$ 42 712.65		
Opex:			$ 54 801.77	$ 17 536.56	$ 40 043.11	$ 12 813.80	$ 29 259.11	$ 9 362.92
Rehabilitation:							$ 780 242.95	
Cumulative:	$ 910 610.02	$ 950 000.00	$ 1 748 252.80	$ 1 170 041.09	$ 2 360 310.18	$ 1 330 822.97	**$ 3 410 153.19**	**$ 1 417 094.99**

From **Error! Reference source not found.** above, it is clear that the cost to purchase and operate an on-site incinerator, which is designed and operated in accordance with international best practice, far exceeds the construction and rehabilitation of a general waste landfill.

9.5 NON-FINANCIAL ADVANTAGES

9.5.1 INCINERATOR

- Reduction in total volume of waste;
- Smaller footprint;
- Fewer methane emissions.

9.5.2 LANDFILL

- Simple to operate and maintain;
- Higher local job creation potential;
- No need for regular maintenance or specialist knowledge;
- No further treatment/scrubbing required either than capping at end of life.

9.6 RECOMMENDATION

There is a move away from landfilling across the world, due to space and ground contamination concerns, however, it is still a widely used, proven and well understood means of disposing of waste, especially if non-hazardous. An onsite incinerator, although a seemingly more elegant and attractive option, in terms of cost, is only comparable to landfilling when heat/electricity is recovered from the process and/or when disposal to landfill is prohibitively expensive/illegal.

SLR believe that should DPMT want to dispose of waste in a responsible manner and in line with international best practice, then the most cost effective option for the disposal of their general waste is via the use of an appropriately designed and constructed landfill as opposed to a stand-alone, fit for purpose, incinerator.

There could be a case however for the discontinued arsenic plant to be converted into an incinerator if it could be incorporated into the already existing flue gas cleaning infrastructure. This falls outside the scope of this study though and would require a complete technical assessment and in depth study to determine its feasibility.

10 CONTRIBUTION TO EIA

Waste management is one of many activities undertaken at the Tsumeb Smelter which may have had, or continue to have, impacts on environmental attributes of the site and surrounds. As a result of the long history of operations and complexity of the site's layout it is challenging to determine and apportion the source of detected impacts on environmental attributes to specific activities. The total, cumulative impact of the Tsumeb Smelter on environmental attributes is being assessed in the EIA for the Smelter Optimization and Upgrade Project. Thus no attempt has been made in this report to assign current impacts to specific waste management activities.

The following section highlights key considerations that should be addressed in the EIA and EMP for the Smelter Optimization and Upgrade Project:

4. Current Operations:
    a. General and hazardous wastes must be separated at source across the Tsumeb Smelter operations.
    b. A 'general waste handling area' (or areas) must be formalised and developed with facilities appropriate to the type and volume of wastes being received and processed.
    c. The 'waste handling area' should be equipped to manage specific hazardous waste streams or a specific hazardous waste sorting area (or areas) must be developed separately.
    d. The open-air burning of general waste must be stopped and a solution implemented for the disposal of the residual general wastes. This development must be viewed as urgent by DPMT and prioritised.
        i. The above could be the general waste landfill site as previously proposed or a modern general waste incineration facility. For the former, it is recommended that the renewal of the environmental clearance from the MET be secured It is recommended that all details from the EMP submitted for the General Waste Landfill Site be included in the current EIA and EMP for the Smelter Optimization and Upgrade Project.
        ii. For the latter the feasibility and design of a general waste incineration facility must be undertaken and a process to secure environmental clearance from the MET commenced immediately.
    e. Repair and then operate the Sewage Treatment Plant as soon as possible. Once operational the current area for effluent discharge should be rehabilitated to remove sewage contaminant risks.

f. Management of the HWDS should continue as per current approval conditions and protocols, with the addition of more focussed groundwater and air quality monitoring programmes for the HWDS;
g. Management of other hazardous wastes not disposed to the HWDS needs to be improved.
    i. DPMT must classify, in terms of the Globally Harmonised System (SANS 10234), all wastes.
    ii. DPMT must ensure the labelling of containers and Safety Data Sheets for all hazardous wastes.
    iii. DPMT must ensure chain of custody records/waste manifest documents for each hazardous waste departing the Tsumeb Smelter
    iv. DMPT must audit each of the external service providers to ensure that those waste management operations are legally compliant.
h. DPMT management must be aware of the capacity constraints of the HWDS and must investigate and implement solutions for providing hazardous waste management or disposal capacity timeously.
i. DPMT should consider implementing a Corporate Social Initiative project in order to enable the establishment of one or more initiatives for the re-use or 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.

5. Construction of Smelter Expansion:
    a. During construction it is likely that around 200 additional staff will be present on site for a period of up to 2 years. These contractors and their activities will result in a significant increase in the generation of wastes. The waste management systems at the Tsumeb Smelter are currently constrained and unable to handle additional volumes. DPMT must either provide capacity in their waste management systems to accommodate this, or specify that each contractor is responsible for their own waste management. If the latter, DMPT must ensure that the contractor's actions comply with waste management legislation and best practice.
6. Future operations:
    a. DPMT management must be aware that the Arsenic Plant termination and Smelter Expansion will increase hazardous waste production, thereby furthering reducing the life of the HWDS (see Section 3.4). Solutions for providing hazardous waste management or disposal capacity must be investigated and implemented timeously. In this regard DPMT are advised to note that determining the feasibility of, securing environmental clearance for and constructing any substantive waste management solution is likely to take 2 to 3 years. SLR recommends that authority approval of the Smelter Expansion be

concomitant to the implementation of an appropriate hazardous waste management solution(s).

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REFERENCES

- *An Economic Evaluation of Incineration as a residual Municipal Solid Waste Management Option in Ireland.* O'Donovan and Collins, November 2011.
- *Arsenic Waste Management facility – External Compliance, Report No: RMS/DPM/AUDIT/11/15.* Resource Management Services, November 2015.
- *Assessment of the Contamination Risks to the Groundwater and Soils at the Tsumeb Smelter, Report No.: JW181/09/C391, Revision 0,* Jones and Wagener, April 2011.
- *Closure Design for the Hazardous Waste Disposal Facility at DPM Tsumeb. Report Number. 12614861.* Golder Associates, November 2013.
- *Dolomite Stability Assessment for Phase 3 of the Hazardous Waste Facility at Tsumeb Smelter, Namibia. (Report Ref: 15-0871.02R01).* GCS Geotechnical, 5 May 2016.
- *Dolomite Stability Assessment for the existing Tailings Storage Facility at Tsumeb Smelter, Namibia. (Report Ref: 15-0871.03R01).* GCS Geotechnical, 10 June 2016
- *Dundee Smelter Expansion Groundwater and Surface Water Specialist Input to EIA. Report No.: 2016-WG28.* SLR Consulting October 2016.
- *EIA of the Tsumeb Smelter Waste Site, Report No664/Rep02.* Synergistics Environmental Services January 2012.
- *Engineering for the Future Development and Extension of the Hazardous Waste Disposal Site. Report Number: 1411226-13839-1.* Golder Associates, September 2015.
- *General Waste Landfill Site at Tsumeb Complex, Preliminary Design Report.* Hill and Associates, June 2012.
- *Incineration of Municipal Solid Waste.* Department of Environment Food & Rural affairs, February 2013.
- *Landfill Suitability Assessment, Tsumeb, Report No 1.* SLR, June 2014.
- *Investigate the contamination risks to groundwater of operations at the Tsumeb Smelter site. Jones and Wagener (JW 49/01/7818 in 2001 and JW 48/11/C391 in 2011).*
- *Stormwater Assessment Study, (Ref. 109185, 2014).* Aurecon, September 2013.
- *Tsumeb Smelter Groundwater Model Update Report, 14-803.* GCS, March 2016.
- *Tsumeb Smelter Expansion: Basis of Design*, (Ref. 207040-00149-00-GE-BOD-0001). Worley Parsons, May 2015

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