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AMENDMENT TO INCLUDE ADDITIONAL LEAD MITIGATION MEASURES (SEPTEMBER 2023) TO THE EXISTING EIA AND EMP FOR THE MINING LICENCE ML 39 – CHANGE OF MINING METHOD AND PROCESSING PLANT AT ROSH PINAH ZINC CORPORATION'S MINE

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RP2.0 EXPANSION PROJECT

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DOCUMENT CONTROL

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ACRONYMS, ABBREVIATIONS AND GLOSSARY

Acronyms / Abbreviations	Definition
AMC	AMC Consultants Pty Ltd
El.	elevation
FS	Feasibility Study
HDPE	High-density polyethylene
IDF	Inflow designed flood
dmt	Dry metric tonnes
EMS	Environmental Management System
HoV	Hill of Value Strategy Optimization
HSEC	Occupational Health, Safety and Environment Commitment
kW	Kilo Watt
LHD	load-haul-dump
LHOS	lughole open stoping
LOM	life-of-mine
NHIES	Namibia Household Income and Expenditure Survey
NIMT	Namibian Institution of Mining and Technology
NUST	Namibia University of Science and Technology
ML	Mining Licence
MME	Ministry of Mines and Energy
MSO	Mineable Shape Optimizer
Mtpa	Million tonnes per annum
NPV	Net Present Value
NSA	Namibia Statistic Agency
NSR	Net Smelter Return
PFS	Pre-Feasibility Study
QP	Qualified Person
RPZC	Rosh Pinah Zinc Corporation
SAG	semi-autogenous grinding
tpd	Tonnes per day
TSF	Tailing Storage Facility
UNAM	University of Namibia (UNAM)
w/w	Weight by weight

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RP2.0 EXPANSION PROJECT

1 INTRODUCTION

Rosh Pinah Zinc Corporation (Pty) Ltd (RPZC) appointed A. Speiser Environmental Consultants (ASEC) to conduct the amendment to the existing Environmental Clearance Certificate No. 0082 (ECC0082). The amendment describes and assesses the changes of the mining method and processing plant at Rosh Pinah Mine. The current mining and processing operation were described and assessed in the "Environmental overview and environmental management system at Rosh Pinah Mine" (ASEC, November 2008). This amendment describes the current lead monitoring activities at Rosh Pinah Mine and states additional mitigation measures to minimise potential lead contamination to the workforce and residents at Rosh Pinah town.

The mining licence No. 39 (ML 39) is held by PE Minerals. PE Minerals and RPZC have an Operational Agreement in which PE Minerals transferred all mining interest to RPZC. The Operational Agreement has been approved in writing by MME in 1999.

The mine operates for 53 years and the present management assigned to manage the legacy of poor environmental performance from earlier management strategies. Over the past 10 to 15 years the focus on environmental issues and impacts have increased and strict environmental legislation has been introduced. Although RPZC mine was set up in the late 1960ies, current Namibian and International legislation requirements have to be met. This document is proof of RPZC's environmental commitment. RPZC has an Occupational Health, Safety and Environment Commitment (HSEC) Policy (2017) outlining RPZC's commitment to continual improvement, management of biodiversity and ecosystems and the undertaking of business in an environmentally sound manner. These commitments are implemented and managed through a certified ISO 14001:2015 Environmental Management System (EMS); the current certification is valid until August 01, 2023. A certified ISO 14001: 2015 Management System is not a legal requirement; however, it is a requirement for IFC Performance Standards (in particular, Performance Standard 1- Assessment and Management of Environmental and Social Risk and Impacts) and good international industry practice.

The Rosh Pinah mine is situated in the Karas Region, 165 km south of Aus, which is 125km east of Lüderitz. **Figure 1** shows ML 39 and Rosh Pinah village. At present RPZC (owned

90% by Trevali) produces 100,000 dmt of zinc concentrate and 10,000 dmt of lead concentrate per annum.

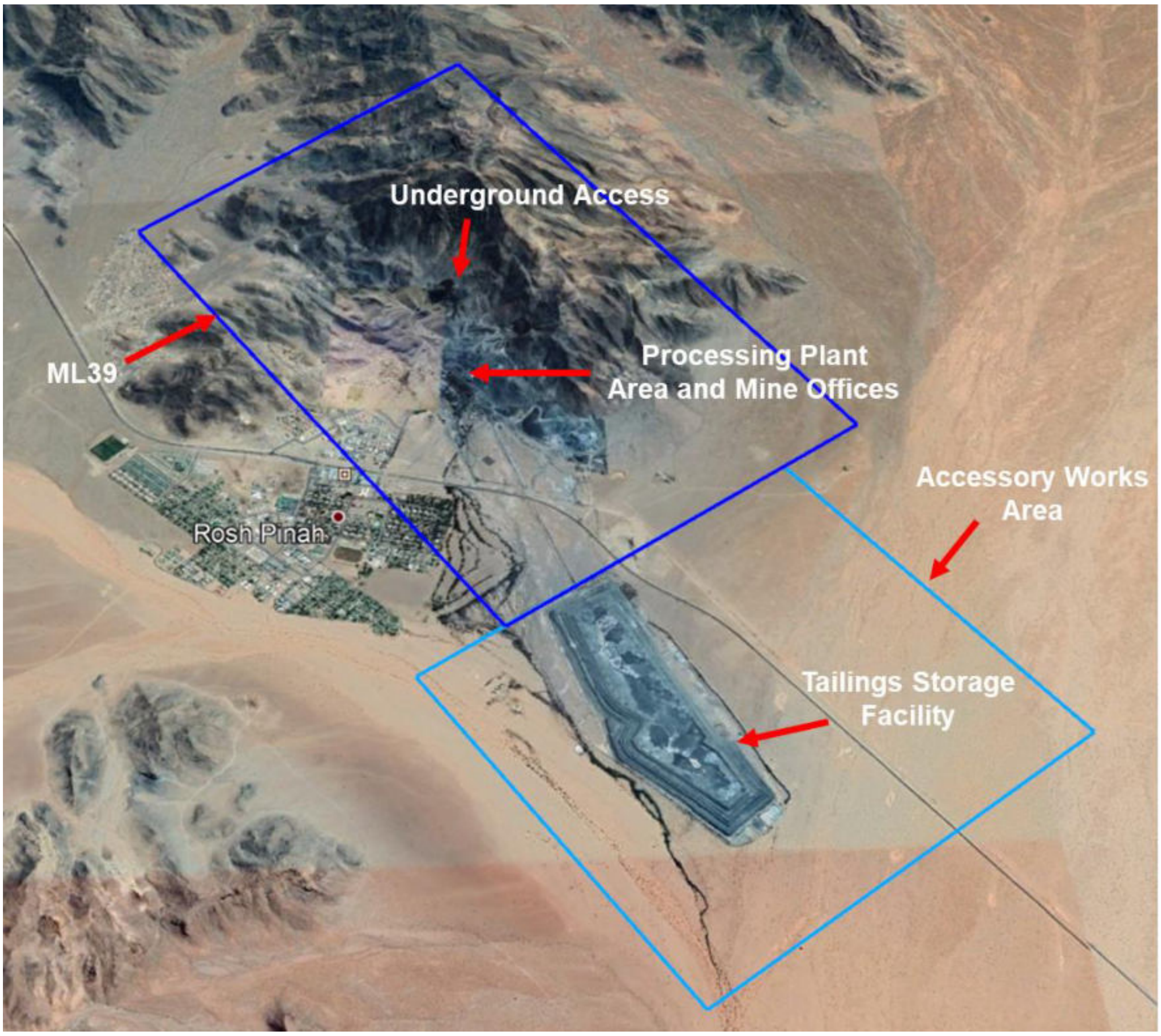


Figure 1: Overview of the Mining Licence ML 39 (dark blue) and accessory works mining area (light blue).

2 MOTIVATION/REASON FOR THE AMENDMENT

On 17 August 2021 Trevali announced positive results from the independent Rosh Pinah Expansion “RP2.0” NI 43-101 Feasibility Study (“FS”) at its 90%-owned Rosh Pinah mine in Namibia. The FS considers the potential for ore production expansion from 0.7 Mtpa to 1.3 Mtpa. The FS is based on a scenario to expand the current throughput through the upgrading of the processing plant, construction of a paste fill plant (including a water treatment plant), surface crushing facilities, and development of a dedicated portal and ramp to the Western Orefield (WF3) deposit.

The Expansion “RP2.0” Feasibility Study includes the following changes at the mine:

Processing Plant: The FS incorporates an upgrade to the comminution circuit to include a new single stage SAG mill and pebble crusher. The upgrade also includes primary crushing upgrades, an ore blending system, along with other circuit modifications to provide increased flotation, thickening, filtration and pumping capacity to achieve the target throughput of 1.32 Mtpa. The upgrade will also include several flowsheet modifications aimed at improving both the concentrate grade and metal recoveries.

Underground Development and Infrastructure: A dedicated portal and decline to the WF3 deposit will be constructed to support the increase to mine production levels and reduce operating costs. The trucking decline is 3.9 km in length, excluding level access and stockpiles. For construction purposes, the decline is separated into five independent legs to enable concurrent development and reduce overall construction time. Internal legs of the trucking decline will be developed off existing development, with take-off positions selected to minimize interaction with the underground operation.

The new trucking decline will act as an additional fresh air intake within the ventilation network and will enable direct ore haulage from the WF3 zone to a new surface primary crusher station utilizing large-scale (60 tonne) trucks. Ore sourced from other areas (EOF, SF3, SOF, and BME) will be transported to the existing underground crushing system using the existing 30 tonne truck fleet and conveyed to surface via the existing conveying system.

Paste Fill Plant: A paste fill plant designed to operate at both the current 0.7 Mtpa and the 1.3 Mtpa targeted throughput rate has been included. The paste plant construction is assumed to commence in Q1 2022 (approximately 12 months before the expansion project's commencement) as it improves both the safety conditions and economics of the current mine configuration as a standalone project. Paste filling the stopes rather that leaving them void will improve ground stability, increase ore recovery, and reduce dilution. It will also reduce surface tailings as a portion of new and existing tailings will be redirected underground to be used as paste fill. It is also critical to fill existing voids (particularly within WF3) to achieve the increased production target and preferred mining sequence considered as part of the expansion project.

Mobile Equipment: The existing small-scale underground trucks and load-haul-dump (LHD) fleet will continue to be used primarily in the current mining areas. This will reduce capital expenditure associated with purchasing new mobile equipment, increasing development profiles and changing the existing underground crushing and conveying system. As mining extends deeper and average haulage distances increase in WF3, new large-scale trucks and LHDs will be purchased for the more efficient transportation of material to surface reducing costs over the life-of-mine.

Figure 2 illustrates the proposed changes to develop the WF3 deposit underground.

Figure 3 provides an overview of the existing infrastructure and the proposed changes investigated in the PR2.0 Expansion Project aboveground. All activities will be within the existing Mining Licence and areas which are already part of the plant operation area.

Filter Press: (also known as the Mini Upgrade Project (MUP)) project included the installation of the following (**Figure 4**):

Lead Regrind Classification Cyclones

The lead concentrate regrind circuit treats lead rougher concentrate. The new regrind circuit classification cyclones recover fines to the overflow (P_{80} of 25 µm) and the coarse cyclone underflow stream at 45 to 50% solids (w/w) is gravity fed to the existing three (3) x 18.5 kW regrind mills. The lead regrind circuit will aim to achieve a target grind of 80% passing 25 µm for the combined mill product and cyclone overflow.

Zinc Regrind Classification Cyclones

The zinc concentrate regrind circuit treats zinc rougher concentrate. The new regrind circuit classification cyclones recover fines to the overflow (P_{80} of 53 µm) and the coarse cyclone underflow stream at 45 to 50% solids (w/w) is gravity fed to the existing 90kW regrind mill. The zinc regrind circuit will aim to achieve a target grind of 80% passing 53 µm for the combined mill product and cyclone overflow.

Zinc concentrate filter

The final zinc flotation circuit concentrate is de-watered in a thickening and filtration circuit. Concentrate is thickened in the existing concentrate thickener to achieve an underflow containing 60% to 65% solids (w/w). Zinc concentrate thickener underflow is pumped to the new concentrate filtration circuit comprised of two (2) filter feed tanks and a horizontal plate and frame pressure filter. The filter is operated on a batch-basis to produce a final zinc concentrate with a target moisture content of approximately 8 to 10% (w/w). Concentrate is stored on the existing drying pads prior to shipment. The zinc filter circuit includes a dedicated compressor and 20 m^3 air receiver to supply high-pressure compressed air to the zinc concentrate pressure filter. Zinc concentrate thickener overflow and filtrate from the concentrate filtration circuit reports to the existing zinc process water storage and distribution circuit.

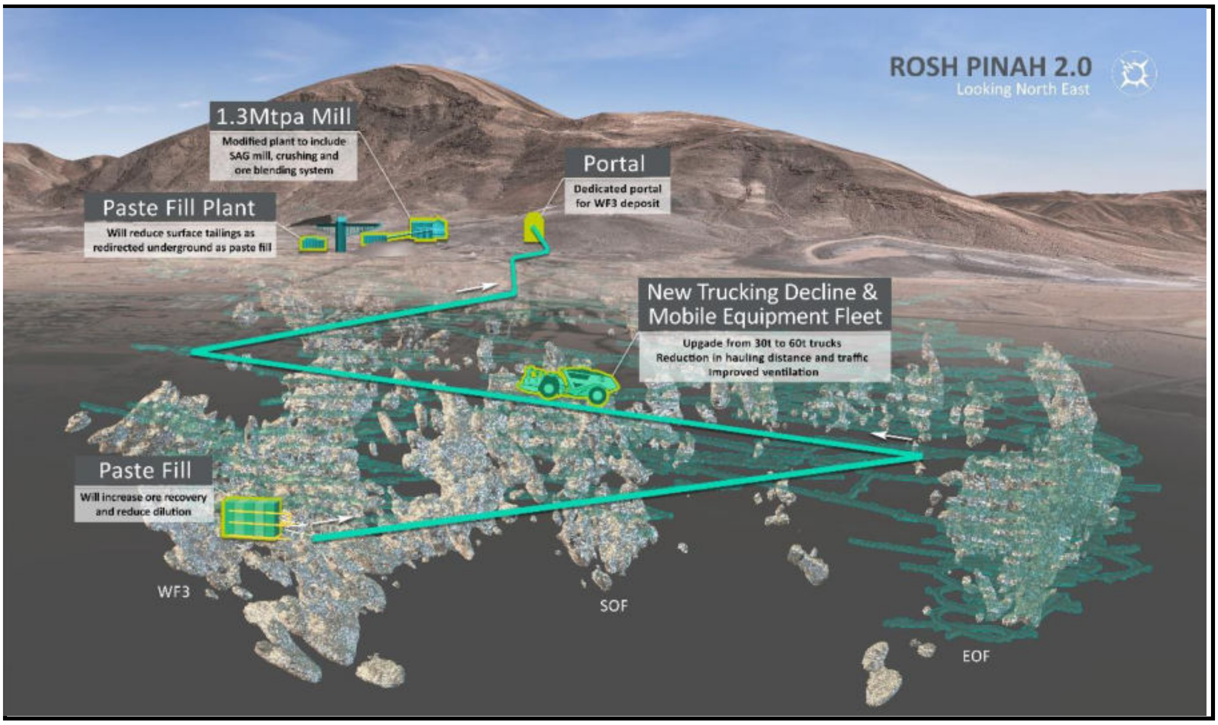


Figure 2: Overview of the proposed PR2.0 Expansion Project to develop WF3 at Rosh Pinah Mine.

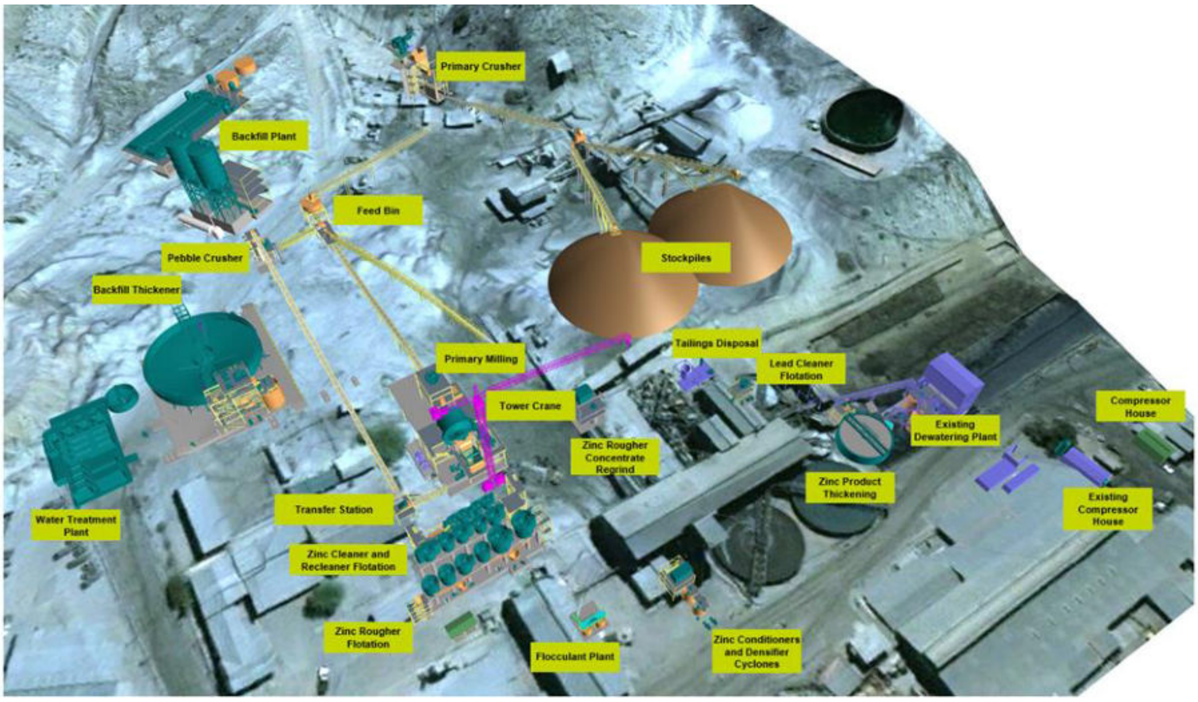


Figure 3: Overview of the existing and new infrastructure above ground.

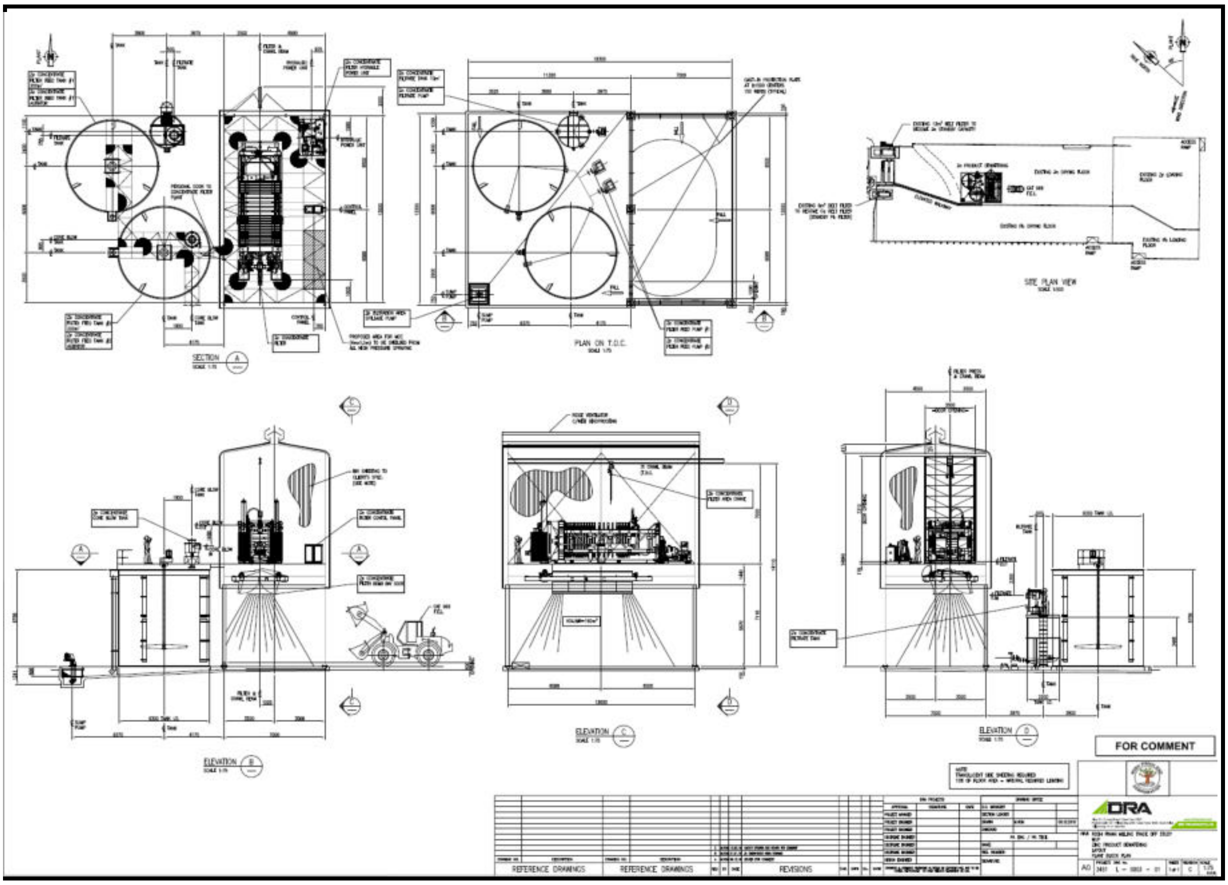


Figure 4: Technical drawing of the filter press.

2.1 Mineral Reserve Estimates

The mining operation opened in 1969 (Mineral Resources of Namibia, 1992) with a declared ore reserve of 4 million tons and an estimated lifespan of eight years. Subsequent exploration revealed a far more extensive mineralised area than originally surveyed and for the past 51 years ore reserve delineation has managed to keep pace with production.

To convert Mineral Resources to Mineral Reserves, mining cut-off grades were applied, mining dilution was added, and mining recovery factors were assessed. Only Measured and Indicated Mineral Resources were used for Mineral Reserve estimation.

The cut-off value was derived using AMC's Hill of Value Strategy Optimization (HoV) process which identified that a cut-off value of $80/t maximized the Net Present Value (NPV). The HoV process evaluated a series of economic value alternatives based on the practical mining options to determine the best strategy for Rosh Pinah. AMC notes that the selected cut-off value is above both the current and projected life-of-mine (LOM) full breakeven cut-off values.

Mr Andrew Hall of AMC is the Qualified Person (QP) for reporting of the Mineral Reserve estimate. The Mineral Reserve is reported in accordance with Canadian NI 43-101 Standards of Disclosure for Mineral Projects and CIM Definition Standards for Mineral Resources and Mineral Reserves (2014). The Mineral Reserve estimate is reported above a Net Smelter Return (NSR) cut-off of $80/t as shown in **Table 1**.

Table 1: Mineral Reserve estimate as at 31 March 2020.

Classification	**Tonnes (Mt)**	**Zn (%)**	**Pb (%)**	**Ag (g/t)**	**Zn (kt)**	**Pb (kt)**	**Ag ('000 oz)**
Proven	6.14	6.26	1.50	18.8	384	92	3,713
Probable	6.21	6.55	1.22	20.8	407	76	4,145
Total	**12.35**	**6.41**	**1.36**	**19.8**	**791**	**168**	**7,858**

3 DESCRIPTION OF THE EXISTING MINING OPERATIONS AND THE PROPOSED CHANGES RESULTING FROM THE PR2.0 EXPANSION PROJECT

3.1 Underground Mining Methods

The current mining method used at Rosh Pinah is lughole open stoping (LHOS) without backfill mining Primary, Secondary, and where appropriate Tertiary stopes, in an underhand (top-down) extraction sequence. Mining without backfill since 1969 has resulted in significant voids within the historical and currently mined areas.

Ore is sourced from five steeply dipping mineralized zones, with an increasing proportion derived from the Western Orefield (WF3), as the Eastern Orefield (EOF), and the Southern and Central Orefield (SF3, SF3, and BME) are depleted.

Access to the production areas is via multiple interconnecting declines that provide fresh air intake into the mine.

The Hill of Valley (HoV) process for Rosh Pinah established the following preferred operating parameters for the underground mine:

- Increase the NSR cut-off to $80 NSR/t.
- Increase ore production to 1.32 Mtpa (from the current 0.7 Mtpa) based on the current Mineral Reserve only.
- Expand the processing infrastructure to match the increase in mine production.
- Transition the current mining method (LHOS without backfill) to LHOS with cement paste fill (pate fill) with extraction in an inverted echelon (bottom-up) sequence to facilitate tight filling of stope voids.
- Use paste fill within the mining cycle to improve regional and local stability, increase resource recovery and reduce the quantity of tailings directed to the tailings storage facility (TSF).
- Develop a dedicated trucking decline from the WF3 orebody to surface to support the increased ore production for the RP2.0 Expansion Project.

The proposed mining method with the inclusion of paste fill has the advantages of higher production, improved local and regional stability, improved mining recovery, reduced dilution and reduced tailings being pumped to the TSF. The extraction sequence will be, where practical, to mine from the centre to the strike extents of each level in an overhand (bottom-up) method. Each stope will be mined and backfilled with paste fill before mining the next stope in the sequence.

AMC used Mineable Shape Optimizer (MSO) software to produce stope shapes based on an $50/t (full break-even) NSR cut-off and $80/t (optimal) NSR cut-off value and practical design criteria. The optimal cut-off is in line with AMC's strategy optimization study (AMC 119015) to maximize net present value (NPV), with the breakeven cut-off used to maximize resource extraction and maintain the production targets. Stope shapes based on the breakeven cut-off were scheduled with lower priority.

3.2 Material handling and new infrastructure associated with the new mining method

AMC's strategy optimization study, and materials handling assessment, identified the preferred materials handling system to incorporate a trucking decline. This would include a larger profile than currently developed to facilitate direct ore haulage from the WF3 orebody to a surface tip point utilising a reduced number of larger capacity, more efficient trucks (60 t). Waste from WF3 will be hauled and tipped into stope voids as per current waste-handling practice.

Components of the trucking decline operation comprise:

- Boxcut and portal.
- Surface primary crusher station.
- 4.1 km independent trucking decline with a larger profile to suit a 60 t truck fleet.
- Underground materials handling station (MHS).

Figure 5 shows an isometric view of the Rosh Pinah mine, including the historical workings and the Reporting case mine design.

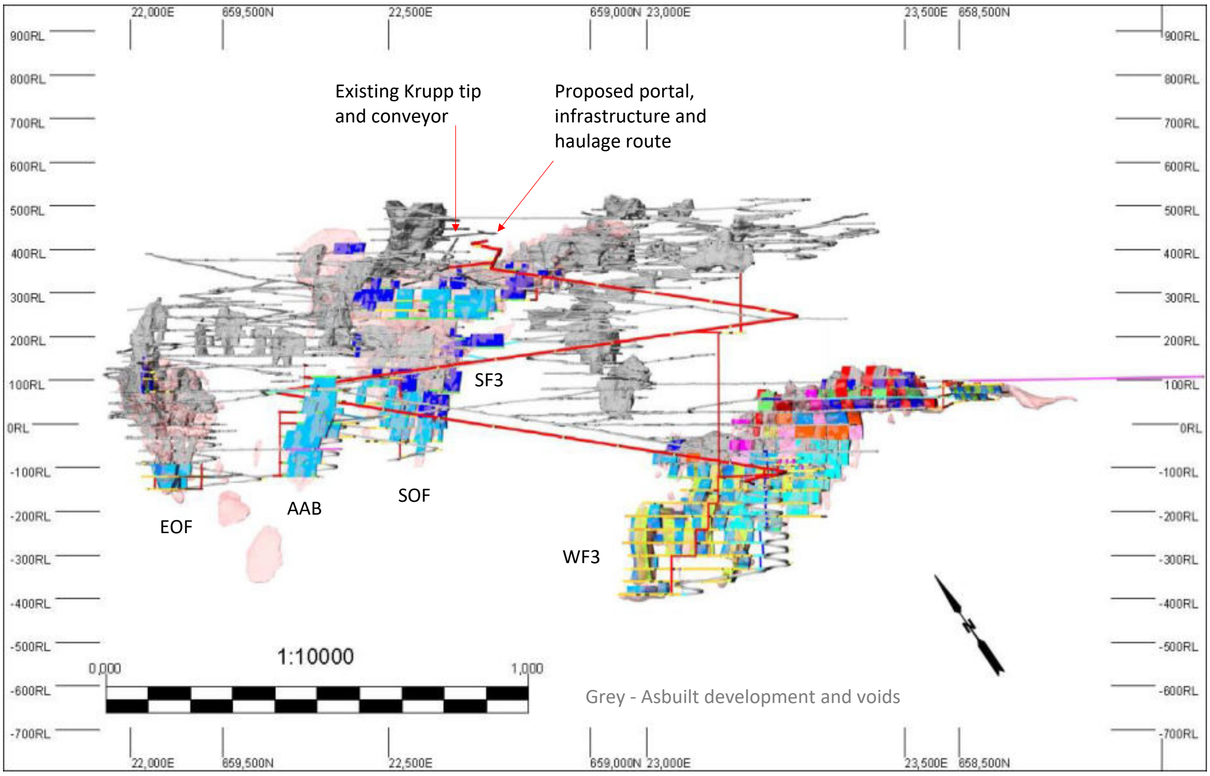


Figure 5: Isometric view showing the Reporting case mine design.

3.3 Overview of the proposed Mineral Processing Operation

The current Rosh Pinah concentrator utilizes a conventional three-stage crushing and ball milling circuit followed by flotation. Future ore production will predominantly originate from the Western Orefield and consequently this ore has been the primary focus in metallurgical test work conducted for the FS.

Metallurgical test work on samples from the Western Orefield has been undertaken as part of the RP2.0 expansion project. The aim of this test work was to derive comminution parameters, establish the optimal primary grind size, further characterise the flotation response, confirm the optimal flowsheet configuration, evaluate the degree of variability and derive grade and recovery estimates.

The key aspects of the concentrator plant design for the FS includes primary crushing upgrades, installation of a new single stage SAG mill circuit, and a number of other circuit modifications to provide increased flotation, thickening, filtration, and pumping capacity. In addition to this the flowsheet also includes several flowsheet modifications aimed at improving both the lead and zinc concentrate grades and metal recoveries.

A crushing circuit trade-off study was conducted to select the preferred circuit for the RP2.0 Expansion Project, based on a variety of criteria. The selected circuit includes a new surface crushing station with blending system to supplement the existing underground crushing and blending system. Ore from the Eastern Orefield would be crushed underground and conveyed to surface while ore from the Western Orefield would be trucked to surface and processed in the new surface crusher station.

Figure 6 provides a high-level summary of the RP2.0 Expansion Project process flowsheet.

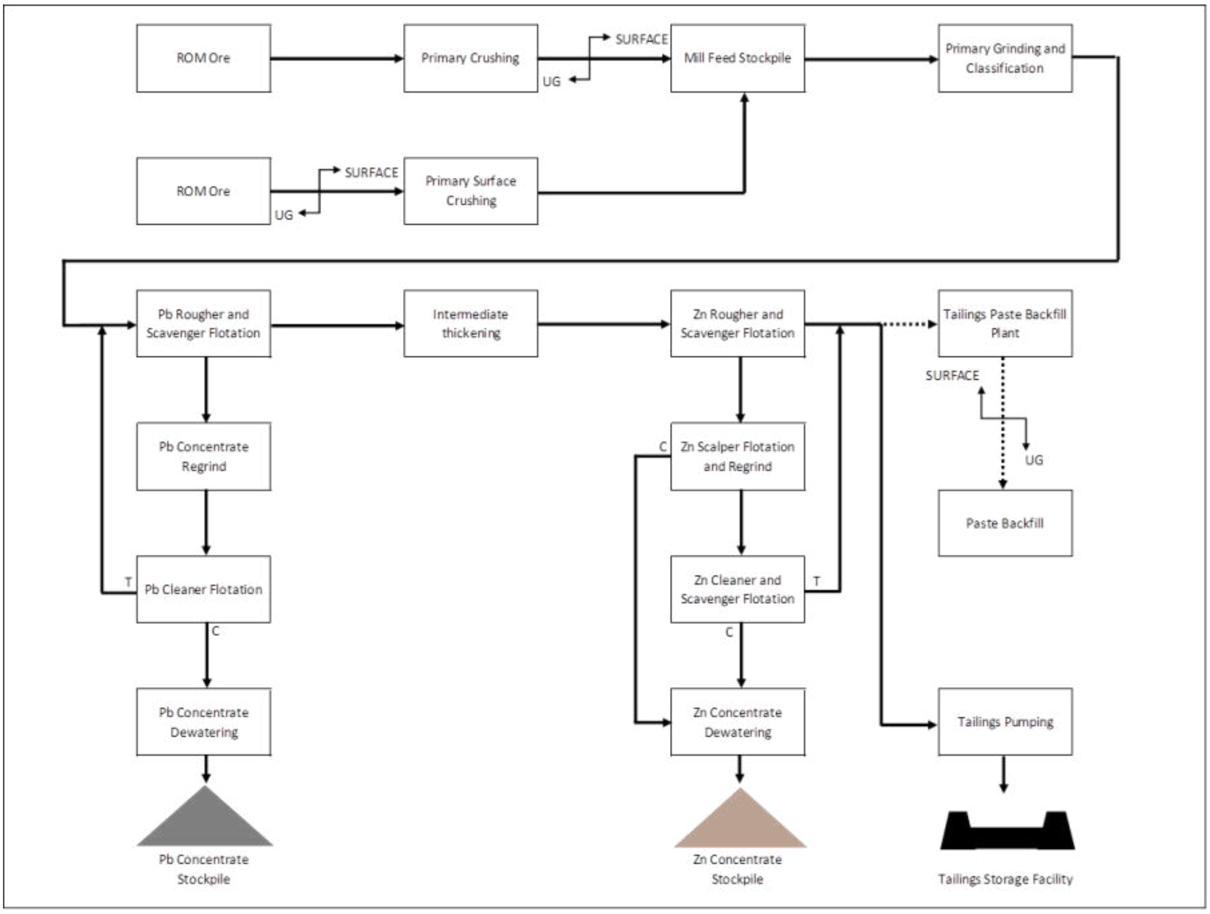


Figure 6: Simplified flowsheet for the RP2.0 Expansion Project.

Although 1.1 Mtpa of ore production is targeted for the FS infill drilling is planned to potentially facilitate the conversion of additional Mineral Resources to Mineral Reserves and support a further increase in throughput to approximately 1.32 Mtpa. As a result, the SAG mill and paste fill plant have been sufficiently sized to allow for a potential future expansion to 1.32 Mtpa.

Comminution variability test work was conducted on approximately 920 kg of rock samples representing the carbonate, breccia and microquartzite ores from the Western Orefield. The comminution test work provided sufficient data to derive SAG mill, ball mill and Vertimill design parameters. The comminution variability test work confirmed the previous test work findings, indicating that the plant feed can be characterized as being of medium (carbonate and breccia) to medium-hard (microquartzite) hardness. The abrasion index indicated that the ore can be classified as having a medium (carbonate and breccia) to high (microquartzite) abrasion tendency.

Flotation test work was conducted on approximately 629 kg of rock samples and 57 kg of ¼ drill core samples representing microquartzite, carbonate, and arkose samples from the Western, Eastern, and Southern Orefields. Most of the samples tested were from the Western Orefield. Bench scale, batch open circuit and locked cycle flotation test work was performed to confirm the optimal primary grind and flowsheet configuration. This development work indicated that a finer primary grind of 80% passing 90 µm in combination with flowsheet improvements aimed at reducing the zinc cleaner circulating load allowed for improvements in grade and recovery.

Locked cycle variability test work on mineralized ore blends has been concluded in a bid to quantify the expected recovery ranges and highlight the degree of variability that can be expected. This locked cycle flotation test work achieved lead recoveries in the range 68% to 88% at a concentrate grade range of 32% to 60%. During the locked cycle tests zinc recoveries in the range 77% to 96% were achieved, with a final zinc concentrate grade ranging between 48% and 56%.

Jameson cell (a high-intensity froth flotation cell) pilot test work has shown that it is possible to produce a zinc cleaner concentrate with a zinc grade of 50%, with zinc recovery ranging from 55 to 60%, in a single stage, when treating a rougher concentrate with a grade of 28 to 30% zinc. Further pilot testing on the lead circuit has shown the potential to produce a lead cleaner scalper concentrate with a lead grade of 40 to 45% at 20 to 25% recovery, when treating a rougher concentrate with a grade of 15 to 20% lead.

Metallurgical performance projections have been derived using discounted locked cycle test results in combination with Rosh Pinah operational performance data. Experience has shown that for RPZC samples, laboratory bench-scale flotation performance is better than that achieved for full scale operations. For this reason, a discount was applied to the laboratory locked cycle test data. The metallurgical performance projections for the RP2.0 expansion and upgrade indicate that an average lead recovery of 68.5% at a concentrate grade of 50% can be achieved while for zinc an average recovery of 89.6% at 51% concentrate grade is expected.

Based on the 2019 to 2021 production data, an average lead recovery of 63.7% at a concentrate grade of 48% and an average zinc recovery of 83.6% at 50% concentrate grade is expected for current operations prior to the implementation of the RP2.0 expansion.

3.4 Paste and Backfill Plant

The paste fill plant will treat the concentrator tailings and is designed to operate intermittently and has been designed to consume up to 0.8Mtpa of tailings as paste fill at an overall utilization rate of 65%. When paste fill is required underground, thickened tailings will be directed to the paste plant.

The paste fill plant uses the total tailings stream pumped directly from the processing plant. The tailings are thickened before further dewatering by vacuum filtration to produce a filter cake. The filter cake is transferred to a continuous mixer with the addition of binder and water to produce a paste fill as per design specifications. When paste fill is required underground, tailings will be directed from the processing plant to the paste plant. The paste plant operator will select the paste fill recipe specified for the stope void, including density, cementitious binder dosing rate and delivery rate. Bulk cement will be stored in a steel silo from where it is delivered to the mixer.

The process design for the Paste Backfill Plant has been developed based on test work findings and design input from AMC. The paste plant design has been based on test work for the RP2.0 tailings stream at a grind of approximately 80% passing 90µm. The test work is considered adequate for the FS requirements. Further pipe loop and strength test work is required to confirm the pumping system design and performance in the early years of operation when treating the current tailings with a coarser grind of 80% passing 150µm. **Figure 7** illustrates the paste fill plant process.

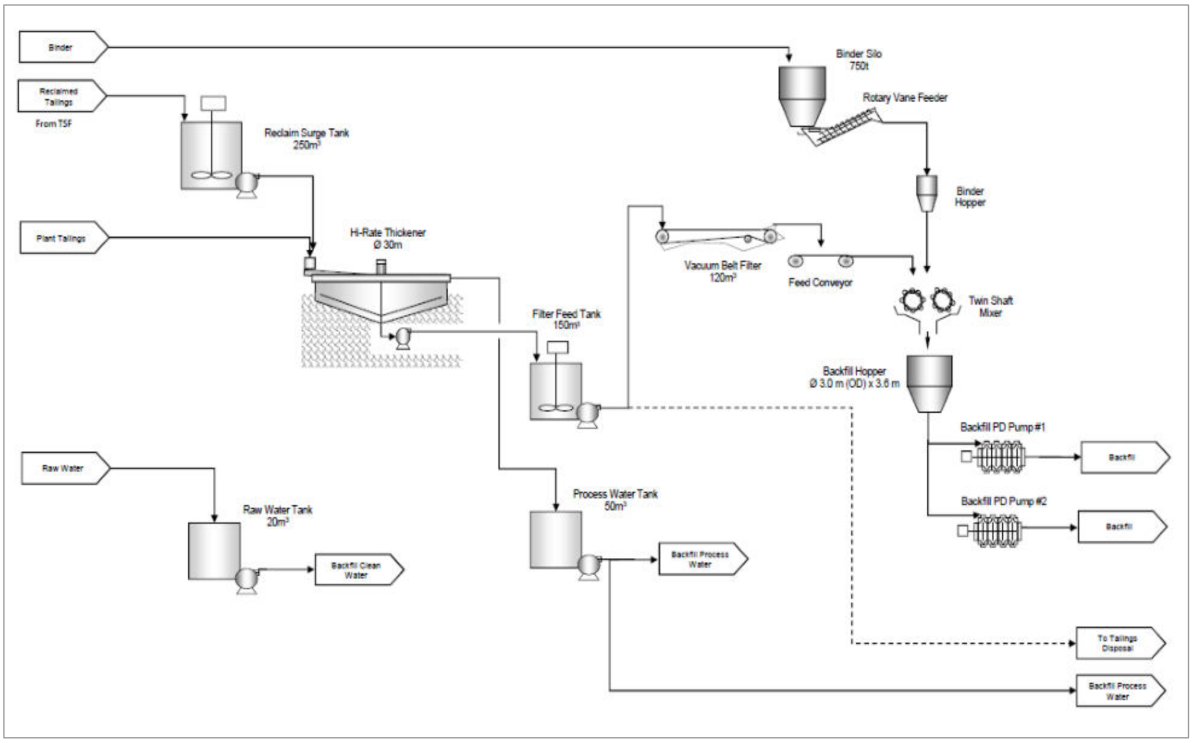


Figure 7: Paste fill plant process flow diagram (Source: DRA 2020).

3.5 PR2.0 Expansion Project Infrastructure

Rosh Pinah is accessible via sealed roads from Windhoek 800 km to the north and from the South African border in the south. The closest commercial airport is located at Oranjemund approximately 105 km southwest of Rosh Pinah, and the nearest railhead is located at Aus on the Lüderitz - Keetmanshoop line, both are accessible by sealed road.

The Property is adjacent to the town of Rosh Pinah, where most employees of Rosh Pinah reside. The necessary infrastructure to support the current operations is in place including security, accommodation, catering, engineering and administration buildings, change facilities, mine ventilation, main power sub-station, mine rescue, water supply, compressed air, underground dewatering, sewage treatment, explosives magazines, water treatment plant, maintenance / repair facilities, storage, laboratory, communications, fuel farm, fire prevention, waste rock dump, and tailings storage facility (TSF).

The existing mine administration facilities are envisaged to be adequate to support the RP2.0 Expansion Project, with only minor upgrades required. The major infrastructure requirements are described below.

Tailings Dam Facility

The Rosh Pinah TSF is operated by a South African contractor, Fraser Alexander Tailings. Tailings slurry from the processing plant is pumped via a pipeline to the TSF and distributed for deposition by means of a ring feed system. The introduction of the LHOS with paste fill mining method is projected to reduce the quantity of tailings directed to the TSF over the mine life. Upon commissioning of the paste fill plant, increasing quantities of tailings can be placed underground in either production voids as part of the mining production cycle or within designated historical voids to reduce tailings quantities to the TSF by approximately 6.5 Mtpa over the LOM. The existing TSF will reach its ultimate storage capacity in August 2022 (Knight Piésold Consulting (Pty) Ltd, Memorandum, 26 January 2021, Remaining Tailings Storage Capacity at the Existing TSF). KP completed pre-feasibility level tailings and water management designs for the proposed Southeast Extension in 2019. The Southeast Extension will be located adjacent to the existing TSF. In 2020, RPZC appointed KP to provide detailed designs for the storage of an additional 3.96 million tonnes (Mt) of fine grind tailings at the proposed Southeast Extension from 2022 through 2031. **The Environmental Clearance Certificate (ECC) for the TSF amendment has been granted on 31 March 2021 by MEFT, and is now part of the overall ECC for Rosh Pinah Mine.**

Klohn Crippen Berger Ltd (KCB) completed a dam safety assurance assessment on the existing Rosh Pinah TSF in May 2019. The key findings of this assessment were that the TSF was generally well managed and there were no signs of distress, and the stability of the TSF was adequate.

Power Supply

The mine power is directly supplied from NamPower (national power utility company of Namibia) utility through its grid system. The mine has an installed capacity of 7.9 MW (an additional 2.1 MW is allocated to the Sendelingsdrif diamond mine on an offtake agreement) with current demand at approximately 7.2 MW fed via two identical 5 MW transformers. Approximately 3.1 MW supplies the processing plant with the rest supplied to the mine, predominately for ventilation. The peak power requirement of Rosh Pinah is forecast to increase to a total load of 14.7 MW. To meet the power demands of the RP2.0 Expansion Project, two 25 MW, 66 kV / 11 kV Power Transformers will be installed in a running / standby configuration. A new 11 kV Distribution Substation will be sized with spare space so that all the 3.3 kV loads can eventually be moved to 11 kV. The transformers will be oversized due to the high ambient temperatures at the site. **An EIA was conducted 2013 by ASEC and an Environmental Clearance Certificate was obtained in May 2014. Unfortunately, the ECC had not been renewed, as the project was not feasible in the past years until now. A reinstatement application (APP 2977) has been submitted by PE Minerals on 26 September 2021.**

Water Supply

Water for Rosh Pinah Mine is sourced from the Orange River by the Namibia Water Corporation via a 23 km of 250 mm pipeline. The FS estimate of the total raw water supply requirement from the Orange River is 90 m^3/hr when the paste fill plant is in operation, increasing to 134 m^3/ hr when the paste fill plant is not operational. The annual average raw water requirement is 107 m^3/hr based on requirement for approximately 63% of the tailings material to be placed underground as paste fill. At the estimated future consumption rate (with inclusion of tailings thickener water treatment at the paste plant), the existing raw water supply system from the Orange River, which has a capacity of approximately 134 m^3/hr, will meet the project's needs.

Ventilation

The ventilation system has been designed to meet the requirements of Namibian Regulations and industry best practices. The current ventilation system includes four exhaust sections, comprising three primary fans installations, one for each mine area (eastern, southern-central, and western) and one associated with the main ore conveyor (Krupp infrastructure). Intake air is via a series of mine portals, with distribution via the ramp / decline network and internal raises. Active working areas are ventilated using auxiliary fans. The new trucking decline, upon completion, will act as an additional fresh air intake and will connect to the fresh air circuit within WF3. An additional surface and internal return air raise (RAR) (4.5 m diameter) within the WF3 mine area network will be required (see **Figure 8**). A total airflow of 687 m^3/s is planned for the LOM.

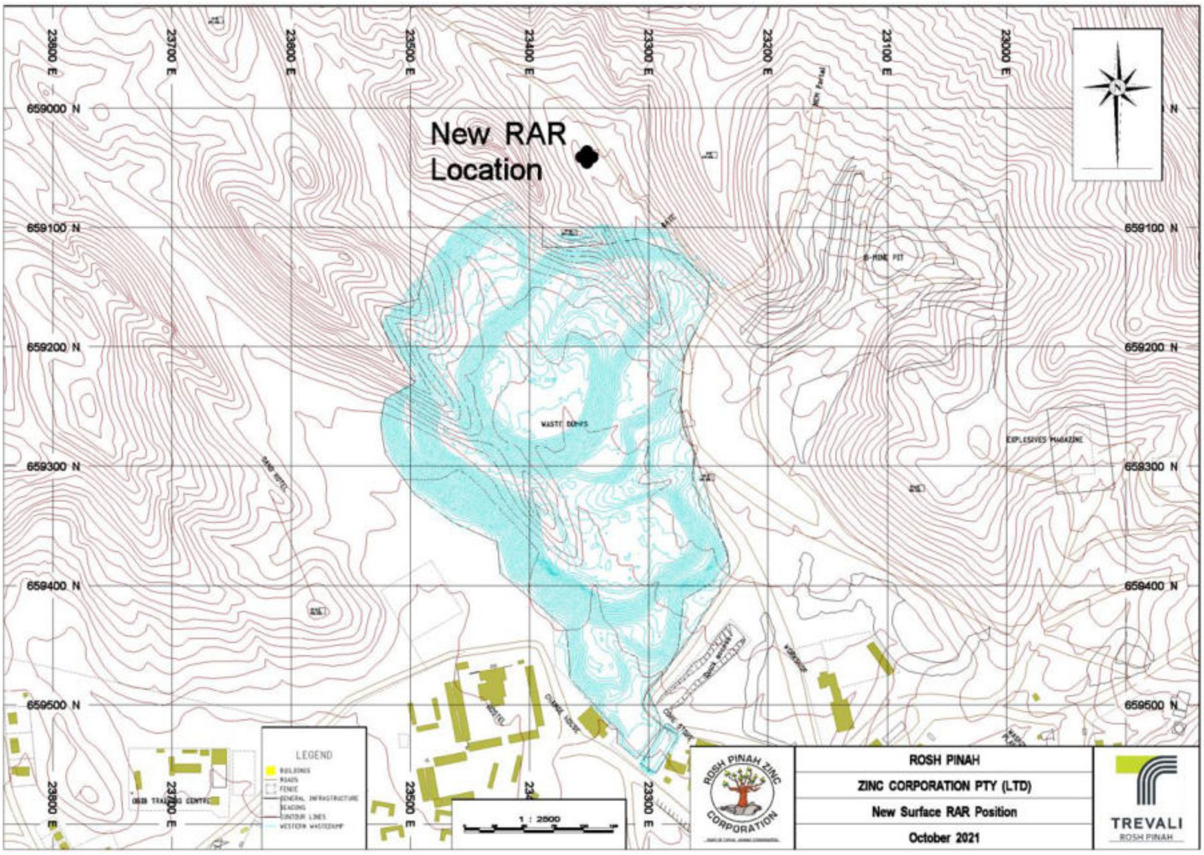


Figure 8: New surface Return Air Raise (ventilation).

3.6 Filter Press

A Technicas Hidraulicas plate and frame filter press was installed in order to replace the zinc vacuum belt filter. This was done in order to optimize dispatches and sales from site with a lower moisture concentrate being produced by the filter press compared to the belt filter.

The filter press was installed on the lead drying floor, the longer-term plan being to strip out the lead belt filter and use the current zinc vacuum belt filter for filtering lead concentrates. The filter press is configured with 28 plates suitable for the current 2000tpd production, with the capability to insert 40 plates when moving over to higher production rates in the future. The image below illustrates the layout of the filter press plant in white graphics on the lead drying floor. **Figure 9** shows the process flow diagram of the filter press.

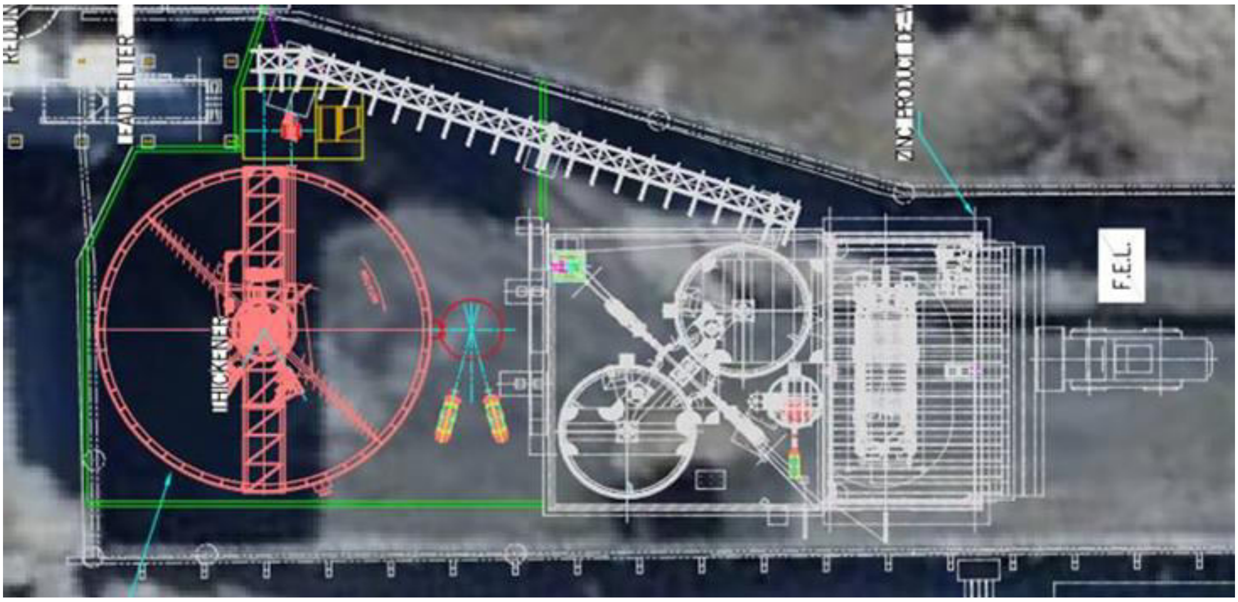


Figure 9: Filter Press process flow diagram.

3.7 Chemicals (Hazardous Materials) Used During Ore Processing

A number of chemicals are used during the flotation process. At the beginning of 2003, discussions began with the supplier Chemquest regarding the disposal of used storage bags. These are currently collected to be shipped back to the manufacturer. **Figure 10** shows the input/output flow diagram for these processes as provided by the mine in 2003. All process water used in the plant is contained within the flotation circuits. Only in the zinc flotation is process water recycled as far as chemically possible. The circulating water becomes progressively enriched in process contaminants and thus needs to be 'bled/removed' periodically and fresh water used to make up the balance. The Zn flotation process needs approximately 81.5 m^3/h of fresh water. The effluent water is piped into the thickener pond before being discharged at the tailings dam.

Ore			
Water			
	Function	**Reagents**	**Area**
	Metal depressant	Sodium Cyanide	Lead flotation
	Bubble stability	Betafroth 608 (Frother)	Zinc and lead flotation
	Collector	Sodium Normal Propyl Xanthate	Zinc and lead flotation
	Gangue depressant	Dextrin	Zinc and lead flotation
	Zinc activator	Copper Sulphate Pentahydrate	Zinc flotation
	Iron depressant	Hydrated lime	Zinc flotation
	Dewatering	SC510A Flocculant	Zinc and lead dewatering

INPUT

Flotation plant

OUTPUT

Lead product

Lead concentrate

Ore process water

Zinc product

Zinc concentrate

ore process water

OUTPUT

Waste rock

Waste water

Reagents

Metal complexes in the concentrator effluent
Silver cyanide complex
Gold cyanide complex
Lead cyanide complex
Zinc cyanide complex
Copper cyanide complex
Iron cyanide complex

Figure 10: Input/Output flow diagram.

3.8 Water Balance

Water is supplied to the mine and village by NamWater, which operates a water treatment plant at the Orange River, 23 km south of Rosh Pinah. The delivery system comprises a single 250 mm-diametre pipeline, with intermediate pump station, feeding a terminal reservoir of 3 600 m^3 capacity. Water for domestic use is further treated and pumped to a second storage reservoir of 600 m^3 capacity. Water to mine staff accommodations are supplied free of charge. However, each household is fitted with a water meter and residents are warned should their water use exceed their allowance.

Raw water consumption rates were estimated using the overall site water balance developed for the Feasibility Study with the inclusion of thickened tailings, paste backfill and water treatment. The modelling shows a reduction in water consumption with the inclusion of paste fill. The total raw water consumption of 1.54 m^3 per tonne milled for current operations (dilute tailings) will reduce to 0.78 m^3 per tonne milled with the inclusion of a tailings thickener, paste backfill and water treatment at the current throughput rate. A further reduction to 0.65 m^3 per tonne milled is expected for the RP2.0 expansion at a higher throughput rate of 1.32 Mtpa. The water consumption figures as outlined reflect the water requirement for both the mine and processing plant.

The RP2.0 expansion FS estimate of the total raw water supply requirement from the Orange River is 90m^3/hr when the paste fill plant is in operation, increasing to 134 m^3/ hr when the paste fill plant is not operational. The annual average raw water requirement is 107m^3/hr based on requirement for approximately 63% of the tailings material to be placed underground as paste fill.

At the estimated future consumption rate (with inclusion of tailings thickener water treatment at the paste plant), the existing raw water supply system from the Orange River, which has a capacity of approximately 135m^3/hr, will meet the project's needs (refer to **Table 2** and **Figure 11** below).

For the overall water balance, the following main water flow aspects need to be considered (among others):

- Current **known and design flows** into and from the flotation plant
- Water-flow rates from the plant to the tailings dam
- **Clean water intake** by mining groundwater
- **Gains as groundwater seepage** into the different mining areas
- **Known water gains** into the plant as **moisture percentage** in the ore mined from the different areas
- **Known water losses** with the zinc and lead ore products as **moisture percentage** in the ore
- **Water gains** from **rainfall** calculated for all open water bodies from monthly rainfall averages for the rainfall station at the mine
- **Water losses** to **groundwater seepage** from dams like the tailings dam, calculated from average hydraulic conductivities measured for the bedrock below the dam
- **Water losses** to **evaporation** from open water bodies calculated according to mean monthly evaporation figures from exposed areas of open water bodies in the mining area
- **Water losses** to **evaporation** from process water uses like dust allaying, washing etc.

Table 2: Water consumption inputs for the water balance

Raw Water Usage (Orange River)	units	Baseline	Baseline + Paste Plant	RP2.0 Paste Plant
Concentrator	m^3/day	2 443	839	1 325
	m^3/t	1.18	0.41	0.34
Mine & Town	m^3/day	733	765	1232
	m^3/t	0.36	0.37	0.31
Averaged Total	**m^3/day**	**3 176**	**1 604**	**2 556**
	m^3/t	**1.54**	**0.78**	**0.65**
Total Min Usage (Paste on)	m^3/day	N/A	1 389	2 164
Total Max Usage (Paste Off)	m^3/day		2 286	3 225
% Paste Plant online		0	76.01	63.35

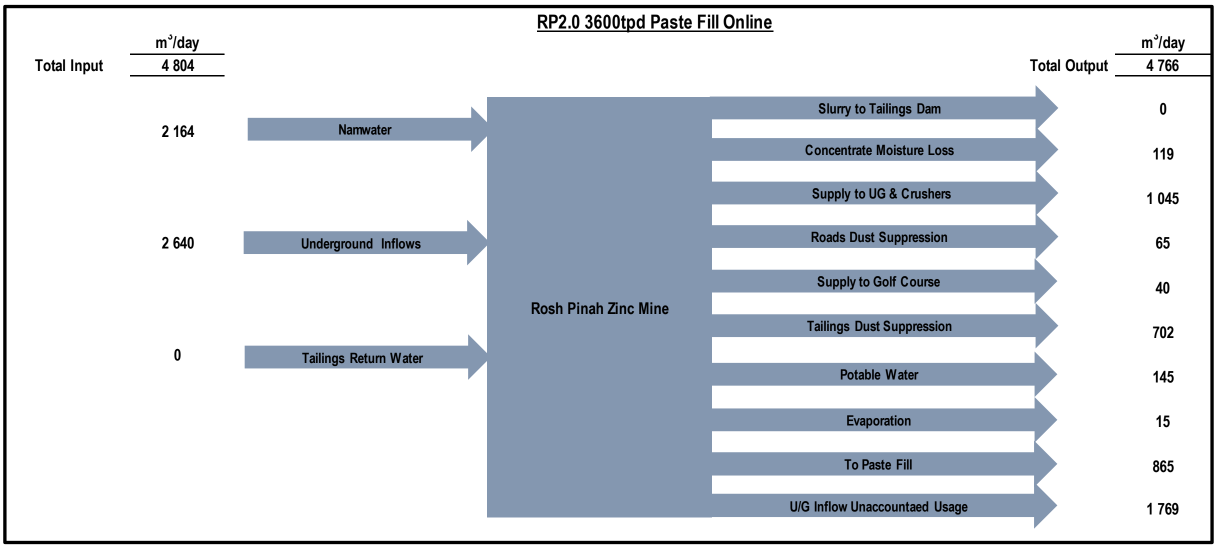


Figure 11: Estimated water balance for the expansion project.

3.8.1 Mine Water Consumption

Table 3 provides the monthly water consumption for 2020. A total of 808,222m^3 were used during this year.

Table 3: Water consumption during 2020. (source: Rosh Pinah Mine)

Date	Total Potable Water Consumption (Mine) m3	Mine / Untreated (m3)	Roshkor Town / Treated (m3)
Jan' 20	5438	94998	30421
Feb' 20	4932	73768	16107

Date	Total Potable Water Consumption (Mine) m3	Mine / Untreated (m3)	Roshkor Town / Treated (m3)
Mar' 20	4808	76019	25797
April' 20	4392	88752	28969
May'20	499	69752	24930
June'20	6078	89333	24267
July'20	5286	57953	18114
Aug'20	8136	86584	17394
Sept' 20	7,157	66,211	22,165
Oct' 20	7,322	65,918	23,260
Nov' 20	6,159	72,971	23,010
Dec' 20	6,017	69,636	20,036
Total	**15,178**	**244,785**	**548,259**

3.9 Laboratory

The laboratory at RPZC ensures that the required standards are met during the flotation process at the plant monitors and advises the plan on the optimal conditions for efficient plant operation. A number of chemicals are used in the laboratory and are handled and stored according to the chemical data safety sheets.

Beginning of 2007 a new effluent water discharge facility was constructed. The waste water is pumped to the tailings dam. In March 2008 construction of the new chemical store was finalized. The new store complies with SABS standards. The standard practice instruction in line with the ISO 14001 Management System was approved in April 2008.

3.10 Service Infrastructure

Service facilities for both the mining and ore processing operations are as follows (see **Table 4**).

Table 4: Service facilities for mining and ore processing operations.

Infrastructure	
Workshops	Mechanical, electrical, transport, boilermakers, mining and town services
Offices	Mining, plant, geology, engineering, administration, security and training
Stores	Warehouse, storage yard, bulk diesel storage tanks, reagent store
	Air compressor plant, electrical generating plant, electrical transformer station (approx. 30 yrs old), oil storage tanks
Conveyors	C5, C7, C9, C10, C12, C13, C14, M2, M3

3.11 Disposal of Workshop Waste

Table 5 provides an overview of the lubricants used in the workshop and average use for 2020. The mine has a number of maintenance workshops which create waste in the form of scrap, waste oils, lubricants, emulsions etc. Oil drained from vehicles is collected in old drums. Rags contaminated with oil and lubricants are disposed of in the old oil collection drums.

Wash water containing oil and emulsions is collected in the workshop oil sumps that overflow through pipes into oil-water separation pits. The oil-water separation pit was upgraded in 2007.

A total of 227,280 litres of used oil is sold and transported with a certified transport company off site for recycling.

Table 5: List of lubricants used in the workshop and average consumption between for the year 2020.

Lubricant type	Average / litre
Lubricant	98,490
Gentool 100	1,890
Oil Gear Gengear 68	7,980
Diesel Lube 700 Super 15W40	61,590
Transfluid, TQ-4, SAE	16,380
Gentool 320 210L	12,180
Gear Lube EP85/140W	420
Power Oil	840
GREASE PETRONAS LICA	2,310
ENGEN GEARLUBE EP 80W/90	1,260

3.12 Disposal of Industrial Waste and Scrap

At the mine a new waste disposal procedure meeting ISO 14001 standards was introduced end 2007. Waste is collected according to waste type. The waste management is carried out by a sub-contractor, EBE (Pty) Ltd. All scoops are colour marked according to the waste type and are disposed of accordingly. **Table 6** provides different waste types and their disposal procedure.

Table 6: Waste types and their disposal procedure.

Waste type	Disposal procedure
Hydrocarbon	Bioremediation plant (operational since 2007)

Waste type	Disposal procedure
Chemicals	Special container, which is sent via a transporting company to Phambili Wasteman (PTY) Ltd in South Africa. A safe disposal certificate is received for each container delivered.
Scrap metal	Scrap yard. Once a year an auction is conducted where scrap metal is sold.
Old oil	Engen Pty Ltd is informed once the old oil tank is full. Oil Skip (Pty) Ltd takes the waste oil to South Africa where it is safely disposed. Exxaro obtains a safety disposal notice.
Batteries	Old batteries are collected at the mine and sent to the supplier in Windhoek for recycling.
Acid cans	Empty acid cans are sent back to the supplier, Lab Scientific (South Africa) to refill.

3.13 Bulk Storage and Handling of Diesel

Diesel fuel is required for the underground mobile mine equipment and surface vehicles. Diesel is stored in two properly constructed tanks, one with capacity of 82,000 l, the other with capacity of 23,000 l. There is a surface refuelling station that allows for refuelling of both light vehicles and heavy-duty mining equipment. A fuel and lube management office is located near to the fuel dispensing facility.

The storage tank is placed on a concrete floor and bunded with an approximately 1.3 m-high concrete wall. At the southern end an outlet exists to drain water or, in the event of spillage or leakage, to pump product out of the containment area. The layout meets SABS standards.

The petrol pumps are situated to the east of the tank. This area has an approximately 2 m-wide concrete floor, but no ring drainage system to collect spillages.

3.14 Power supply

The mine power is directly supplied by the National Power Utility Company of Namibia (NamPower) from its grid system. Rosh Pinah has reserved capacity of 7.95 MVA with current demand at approximately 7.2 MVA fed via two identical 5 MVA transformers. Approximately 3.1 MVA supplies the processing plant with the rest supplied to the mine, predominately for ventilation.

A spare 5 MVA transformer was purchased in 2014 and serves as back-up for the existing units. No emergency power supply exists.

The electrical reticulation infrastructure is summarized as follows:

- A 400 kV NamPower line supplies power from the Kokerboom Substation, close to Keetmanshoop, to Obib at Skorpion Zinc, from there the town of Rosh Pinah is supplied via a 66 kV line.
- A 66 kV incomer line supplies power from the Obib substation, located at the Skorpion Zinc mine, to the main substation at RPCZ, via the Rosh Pinah Town Substation.

- Power is stepped down to 3.3 kV through two 5 MVA transformers and supplied to the processing plant (milling substation), the crushers (Secondary and Tertiary substations) and the eastern Orefield substation (main distribution to underground).
- Underground reticulation occurs on the various levels with 3.3 kV to 550 V substations.

NamPower has advised that the overhead line conductors between the NamPower sub-station at Skorpion Zinc and RPZC are 'Hare' specification. The thermal capacity of the line is calculated at 40 MVA but, due to the length of the line, volt drop considerations and its age, this limit has been assumed to be 20 MVA.

Of the current 20MVA line capacity, 10MVA is reserved for the Rosh Pinah Town and Orange River water pumping schemes, 7.95MVA for RPZC the remainder of 2.1 MVA to the Sendelingsdrif diamond mine on an offtake agreement.

An application to increase the RPZC reserved capacity from 7.95 MVA to 18.5 MVA has been submitted to NamPower. Nampower has agreed to increase the NMD to 18.5MVA. In order to save time, a self-build option was negotiated to build a new 66kV feeder bay at the OBIB Substation and a new 66kV Overhead Line from OBIB to Rosh Pinah this will be approximately 18km. For the Paste Plant, Nampower has agreed to increase the NMD from 7.95MVA to 10MVA.

The power requirement of the RP2.0 Expansion Project is forecast to increase by 2.1 MVA in 2023 as a result of a paste plant addition, 1.8 MVA in 2024 due to increased underground ventilation requirements, and 5.8 MVA in 2024 due to the planned SAG Mill, surface crusher installation and processing plant upgrades. The peak design load is estimated to be 16.9 MVA as shown in Figure 18.3. Power Factor correction will be installed to correct the power factor of RPZC to 0.96.

Additionally, the load profile includes an allowance for an underground growth rate of 1% per annum with no processing plant growth. From these projections, the load forecast in 2032 is estimated to be 18.3 MVA.

Figure 12 shows the estimated power forecast for the RP2.0 Expansion Project.

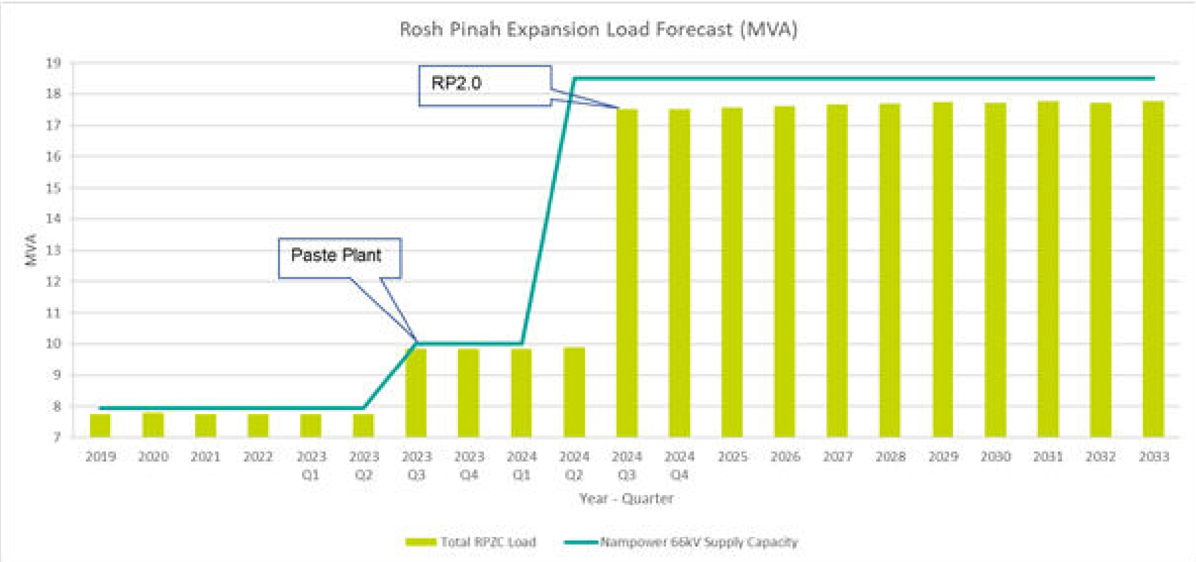


Figure 12: Rosh Pinah Mine estimated power forecast.

The existing maximum capacity of 7.9 MW is insufficient to meet the forecast power demands. The current distribution voltage is also 3.3 kV, which is causing voltage drops in the underground operations. In addition, the existing main substation was built in the 1960s and is reaching the end of its useable life.

In order to meet the power demands of the RP2.0 Expansion Project, two 25 MVA, 66 kV / 11 kV Power Transformers will be installed in a running / standby configuration. The new 11 kV Distribution Substation will be sized with spare space so that all the 3.3 kV loads can eventually be moved to 11 kV. The transformers will be oversized due to the high ambient temperatures at the site.

3.15 Concentrate Storage, Loading Site and Dispatch

Zinc and lead concentrates are placed on a series of drying floors located adjacent to the processing plant where the concentrate is dried and stockpiled. A front-end loader is used to load the concentrate onto trucks for transport 300 km to the port of Lüderitz where RPZC has a dedicated concentrate storage shed. The concentrate is then shipped to international markets.

The ore storage and loading area at Walvis Bay has been upgraded meeting ISO 14001 requirements. Additional precautionary measures are that the trucks loading bins is covered by tarps are covered before leaving the mine. Monthly safety and rehabilitation reports are provided to plant operations. Internal audit is conducted on an ongoing basis by plant operations and SHE department.

4 BIO-PHYSICAL AND SOCIAL ENVIRONMENTAL ADDITIONAL INFORMATION TO THE 2008 EIA AND ASPECTS PERTINENT TO THE PR2.0 EXPANSION PROJECT

4.1 Climate

RPZC mine is situated in a predominately winter-rainfall region. The winds of the south Atlantic anticyclone system and cold Benguela current are the main elements influencing the area's climate.

The climate of the wider Rosh Pinah area is arid with low unpredictable rainfall, mainly occurring between April and August. Summers are hot and winters are mild. A large diurnal temperature range is exhibited in the winter months resulting in early morning mist and heavy dew.

4.1.1 Rainfall

The mine has received an average of 39.5 mm of rain per year over the last 10 years, where data were recorded. The highest average rainfall events during these years usually occur in January and between May and August. However, as Rosh Pinah falls within the southern part of the winter-summer rainfall area, rain events can be expected throughout the year. The highest rainfall event – 100 mm was recorded in January 2011. The rainfall data shows that run-off events are uncommon. The ephemeral channel west of Rosh Pinah flowed in January 2011 for the first time since 2000. **Table 7** provides rainfall data recorded at the rain gauge at RPZC mine.

Table 7: Rainfall from 2008 - 2020/mm/Year - Rosh Pinah (source: RPZC weather station).

	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	14								2.5	2	9.5		
2009	59.6		12	7.5		2	7	5.5	6.5	5.6	0.5	13	
2010	13.7		3.6	1.5			2.5	4.5		1.6			
2011	100	2.5		12.8		48.5	1	3	28.2			4	
2012	34.1			11.5			2.5	9	7.5	3.6			
2013	69.5				27		3		29.5	9			1
2014	29.3	6		8		3	6	5.5				0.8	
2015	11				6		5						
2016	No data were recorded												
2017													
2018													
2019	10	0	3	0	0	7	0	0	0	0	0	0	0
2020	54	4	0	0	0	20	8	22	0	0	0	0	0
Total	395.2	12.5	18.6	41.3	33	80.5	35	49.5	74.2	21.8	10	17.8	1

4.1.2 Evaporation

The potential annual evaporation in the Rosh Pinah area is approximately 3,000 mm. The maximum is during the summer months and progressively declines during the autumn, winter and spring. The evaporation decreases slightly – to approximately 2,600 mm – towards the coast due to the presence of fog (Pallet, 1995). Comparing the average annual precipitation figure of 39.5 mm with the potential annual evaporation it becomes clear that overall, there is a net loss of water within the Rosh Pinah area.

4.1.3 Temperature

Airshed Planning Professionals interpreted the available data measured at the weather station at RPZC mine. Data were provided from 2011 to January 2021.

Diurnal and average monthly temperature trends are presented in **Figure 13**. Maximum, minimum and mean temperatures for the study area are given in **Table 8**, as 41°C, 3.8°C and 19°C respectively, based on Rose Pinah weather data for the period Sep 2011 – Aug 2019; Jan 2020 – Jan 2021. Average daily maximum temperatures range from 41°C in January to 30°C in June, with daily minima ranging from 13.6°C in March to 3.8°C in July. For the month of May, no data was recorded for the entire dataset. Ambient air temperature decreases to reach a minimum at around 03:00 i.e., just before sunrise.

Table 8: Hourly minimum, maximum and average hourly temperatures based on Rosh Pinah meteorological data (Sep 2011– Aug 2019; Jan 2020 – Jan 2021).

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Minimum	13.2	12.6	13.6	11.3	0	7.5	3.8	6	8.9	9.1	10.5	12.9
Maximum	41	40	40.9	35.5	0	30	30.4	36.6	35.3	30	39.8	37.7
Average	19.7	5.2	19.4	19.6	0	18.8	18.2	18.2	17.7	19.4	19.4	19.66

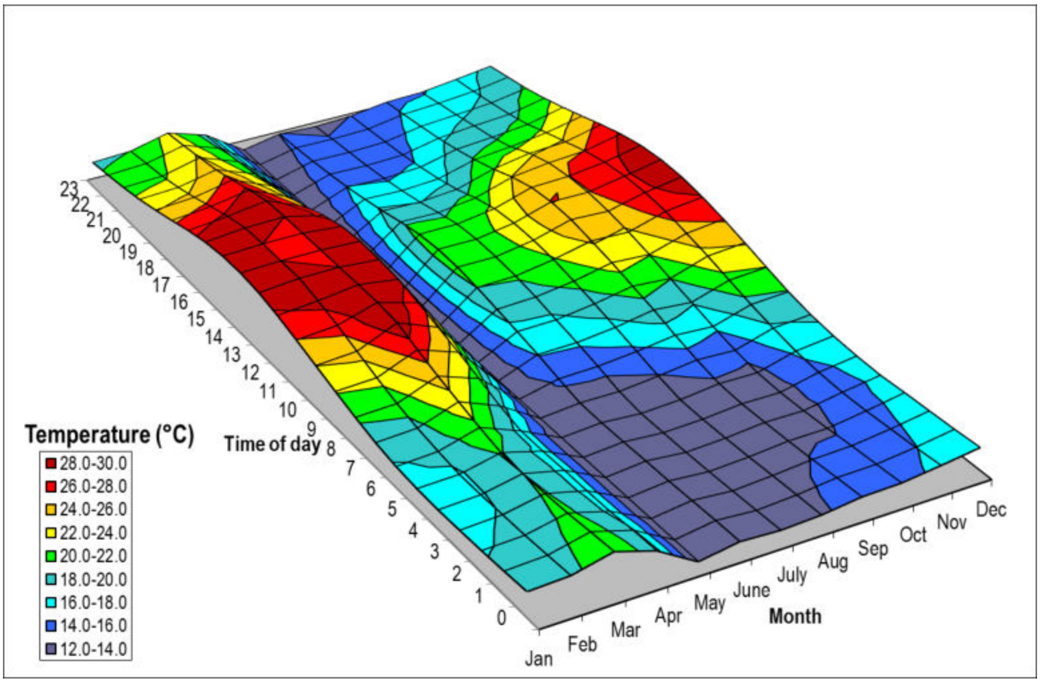


Figure 13: Daily average temperatures based on Rosh Pinah meteorological data (Sep 2011 – Aug 2019; Jan 2020 – Jan 2021).

4.1.4 Fog

Namdeb has recorded an average of 100 days of fog per annum at Oranjemund. Along the coastal areas of the Sperrgebiet, fog occurs most often in February and March. Often the fog also moves many kilometres inland along the Orange River and calculations conducted for the Rosh Pinah Landfill Study (WSP Walmsley, 2001) suggested that fog occurs about five or more times per month during February and March at Rosh Pinah.

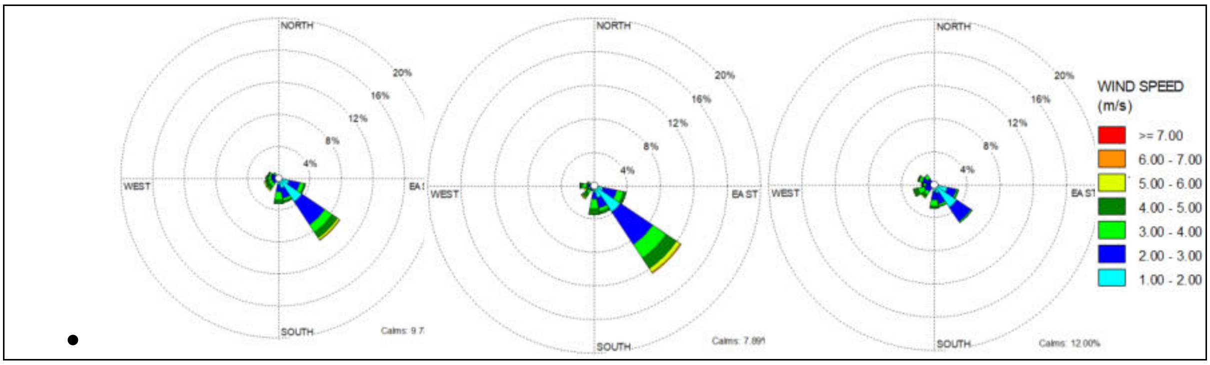
4.1.5 Surface Wind Fields

Wind roses comprise 16 spokes, which represent the directions from which winds blew during the period. The colours used in the wind roses below, reflect the different categories of wind speeds; the red area, for example, representing winds between higher than 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred refers to periods during which the wind speed was below 1 m/s.

Period, day-time and night-time wind roses for the study area, based on Rosh Pinah meteorological data for the period: Jan 2020 – Jan 2021 are depicted in **Figure 14**. This year was selected since it has the highest data availability (40%). Yearly wind roses are provided in **Figure 16** and represent where data for a full calendar year was available. The seasonal variability is based on the period Jan 2020 – Jan 2021 and is shown in **Figure 15**.

Weather data from the Rosh Pinah weather station had very low data availability with 54% of the dataset recorded as zero, and according to the US EPA the data availability should at least be 90%. This explains the missing data from the northerly sector of the wind roses shown in **Figure 15**. Possible reason for this missing data could be due to malfunctional weather station or possible obstacles blocking the northern sector of the weather station.

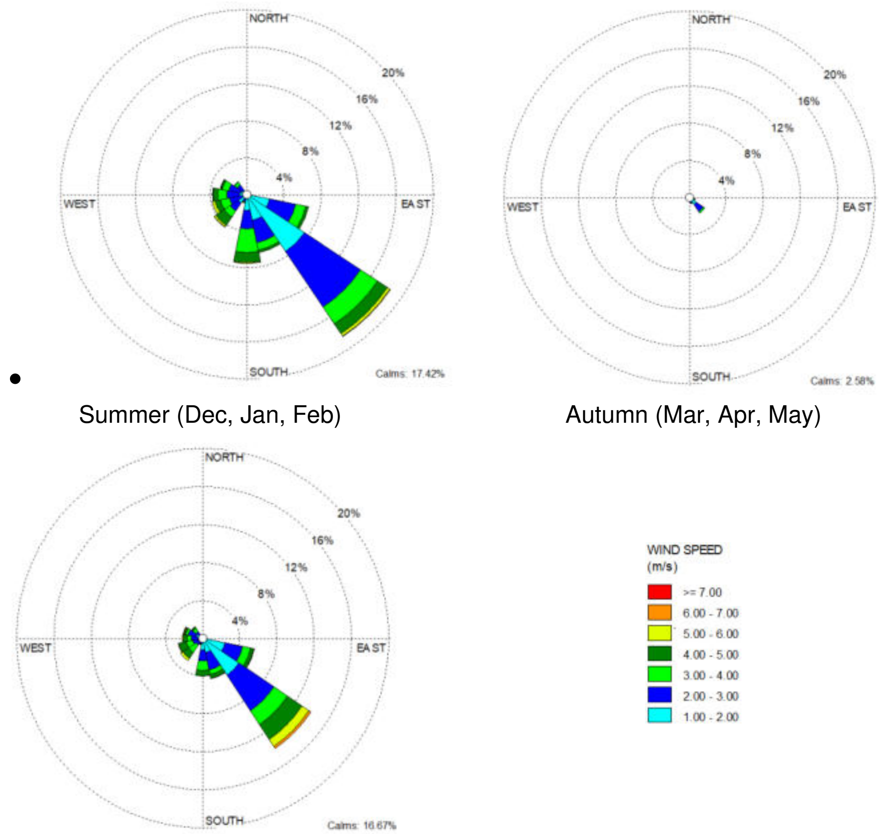
- During the Jan 2020 – Jan 2021 period, the wind field was dominated by frequent winds from southeast, east-southeast, south-southeast and south, with less frequent winds from the west. During the day wind is predominantly from the southeast, followed by south-easterly winds with strong wind speeds and little calms conditions recorded at 8% (**Figure 14**). During the night, wind from the southeast decreases with more frequent winds from the west-northwest and west-southwest. Day- and night-time average wind speeds are 2.18 m/s and 1.58 m/s, respectively with an average wind speed of 1.91 m/s and a maximum of 6.5 m/s. Winds are strongest during the day with more frequent calm conditions during the night.



(a) Period Jan 2020-Jan2021	(b) Day-time Jan 2020-Jan 2021	(c) Night-time Jan 2020-Jan 2021

Figure 14: Period, day- and night-time wind roses based on the Rosh Pinah meteorological data (Jan 2020 – Jan 2021).

- Seasonal wind roses for the period of Jan 2020 – Jan 2021 are provided in Figure 15. There is only data for the months of January to March, and October to December. Thus, the only two seasons which is adequately represented are Summer and Spring, with autumn only represented by the month of March and no data for the winter months. The prevailing south-easterly winds are reflected in the summer and spring data, with more frequent winds from the seasonal dataset reflects a similar trend between summer and spring month roses. During summer months winds were dominantly from east-southeast, southeast and south. During autumn months the data availability was very low hence the wind rose show a lot of missing data. The spring months showed a larger variation in wind direction with similar winds as the summer months.



Summer (Dec, Jan, Feb)

Autumn (Mar, Apr, May)

Spring (Sep, Oct, Nov)

Figure 15: Seasonal wind roses based on the Rosh Pinah meteorological data (Jan 2020 – Jan 2021).

- Over the individual years (2011; 2013; 2014; 2016; 2017 and 2020) the prevailing wind field is from the southeast with some years reflecting easterly, southerly and westerly winds (Figure 16). The reason for not all the years to reflect other wind directions are likely due to the little data availability for the years. The most credible years are 2017 and 2020 (even though the data availability for these two years are also very low at 34% and 40%, respectively).

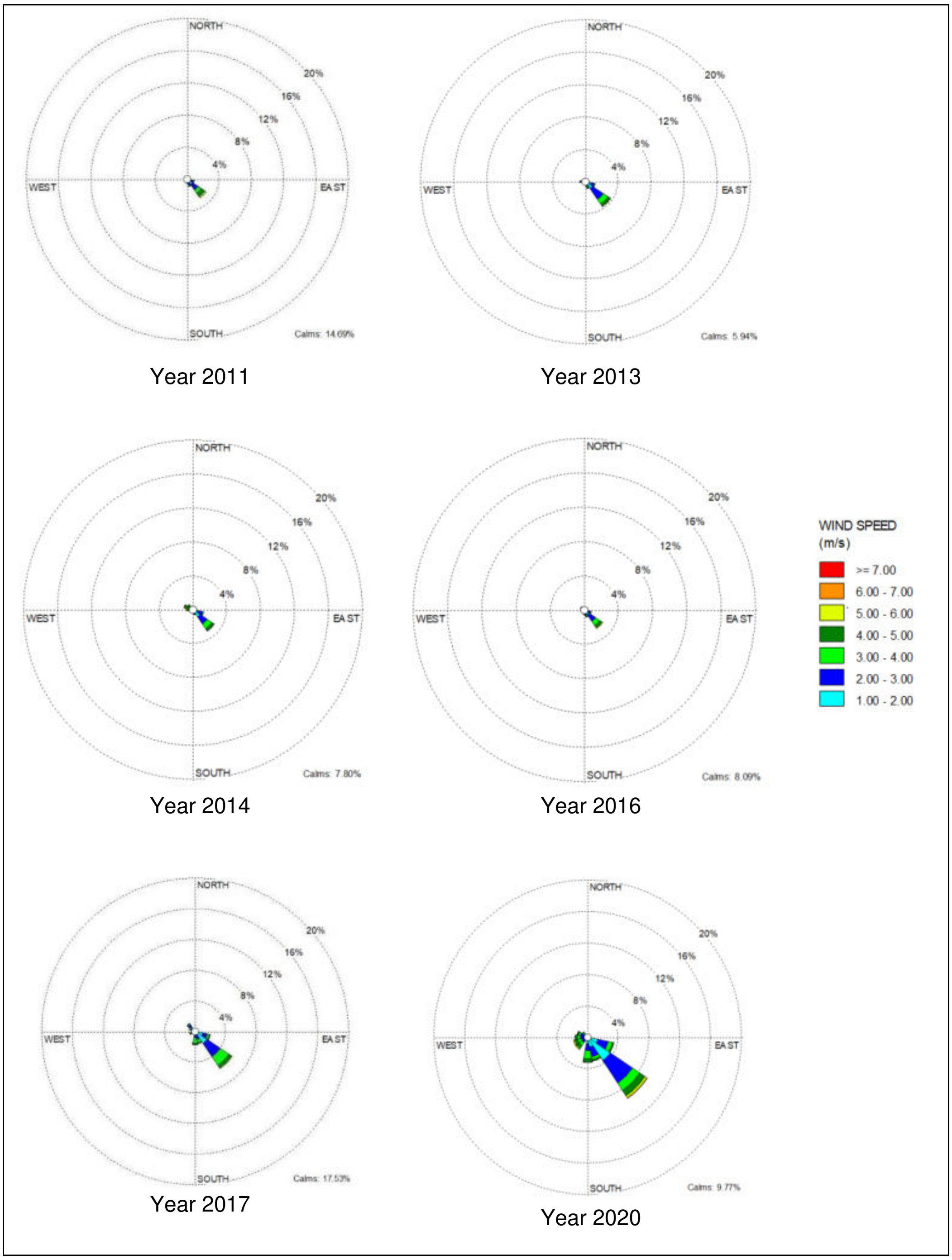


Figure 16: Yearly wind roses based on the Rose Pinah meteorological data (2011; 2013; 2014; 2016; 2017; 2020).

According to the Beaufort wind force scale (https://www.metoffice.gov.uk/guide/weather/marine/beaufort-scale), wind speeds between 6-8 m/s equate to a moderate breeze, with wind speeds between 14-17 m/s near gale force winds. Based on the available data for the period Sep 2011 to Jan 2021, wind speeds fell mostly in the 2-4 m/s category with winds exceeding 3 m/s only for 2.9% (**Figure 17**). Winds exceeding 5 m/s occurred for 0.3% of the time, with a maximum wind speed of 10.05 m/s (which was recorded in 2013). The average wind speed over the period was 1.48 m/s. Calm conditions (wind speeds <1 m/s) occurred for 7.12 % of the time.

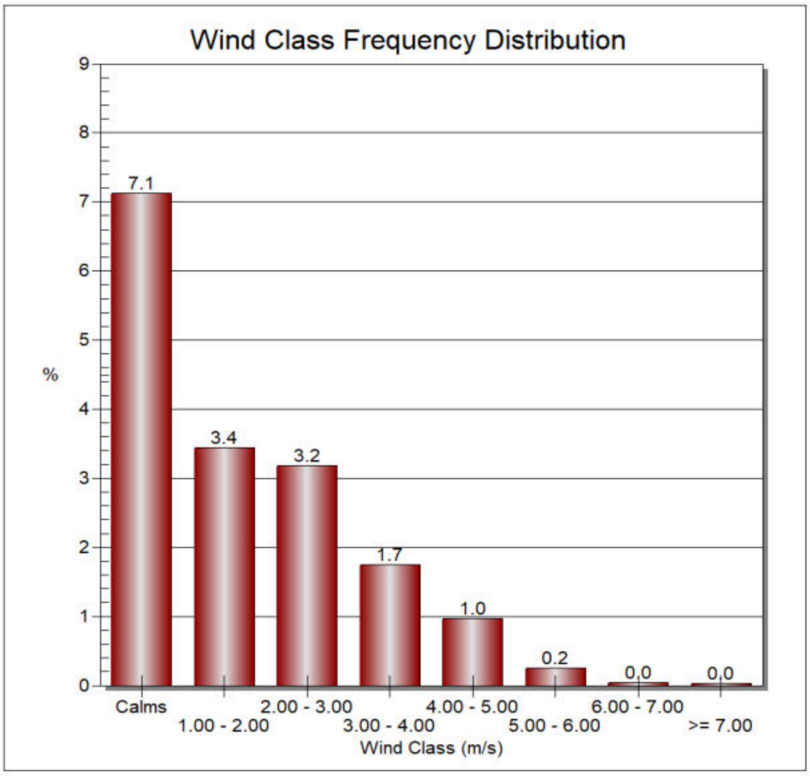


Figure 17: Wind speed categories based on the Rosh Pinah meteorological data (Sep 2011 – Jan 2021).

4.2 Topography

The mine site lies at the base of the southern tip of the prominent, NW-SE-trending 'Rosh Pinah Mountain', which forms part of the Namusberg mountain range. The crest of this peak rises over 500 m above the surrounding plain and forms a watershed which drains to the east and west. To the north of Rosh Pinah lies the mountain massif of the Huib-Hoch Plateau, to the east the Hunsberg Mountains and to the west the Obib Mountains.

A 3-4 km-wide, NW-SE-trending sandy plain forms a valley between the Rosh Pinah Mountains and the Obib Mountains to the west and south-west. A major drainage channel flows along the length of this, just west of the edge of the extended Rosh Pinah village. This system is also fed by two smaller catchments, one that drains from the west and the northern extension of the Obib Mountains and the other that flows from the east, just north of Rosh Pinah. The last time water flowed in the channel west of Rosh Pinah was in January 2000, when the stream draining the northern end of the Obib Mountains flowed as a result of a significant thunderstorm (pers. comm. M Louw). A series of ephemeral drainage channels flowing off the Namuskluft Mountains through a sandy plain joins the main Rosh Pinah drainage system just south of the village and tailings dam. Rosh Pinah falls within the Orange

River catchment, and the ephemeral streams and rivers in the area drain southwards into the Orange River.

4.3 Geology

4.3.1 Regional Geology of the Rosh Pinah Area

In the following a summary of the regional geological setting is provided using various reports such as “Promising Patterns – A new approach to the mineral potential of southern Namibia” (Palett (ed), 1997) and information provided in discussions with staff of Exxaro. The Rosh Pinah area falls within the Gariep Belt, formed by plate-tectonic processes. The initial rifting phase is characterised by coarse clastic sediments in fault-bounded sub-basins and rhyolitic effusions along the rift fault. This event was followed by a stage marked by marine volcano-sedimentary sequences inter-fingering with and overlain by clastic-carbonatic sequences. In the next stage the opening of the proto-Atlantic with the formation of basaltic oceanic crust occurred. The closure of the proto-Atlantic – combined with uplifting of the hinterland – is characterised by the accumulation of a thick pile of turbiditic clastic sediments. Finally, the whole sequence was folded and thrusted over the foreland in the east.

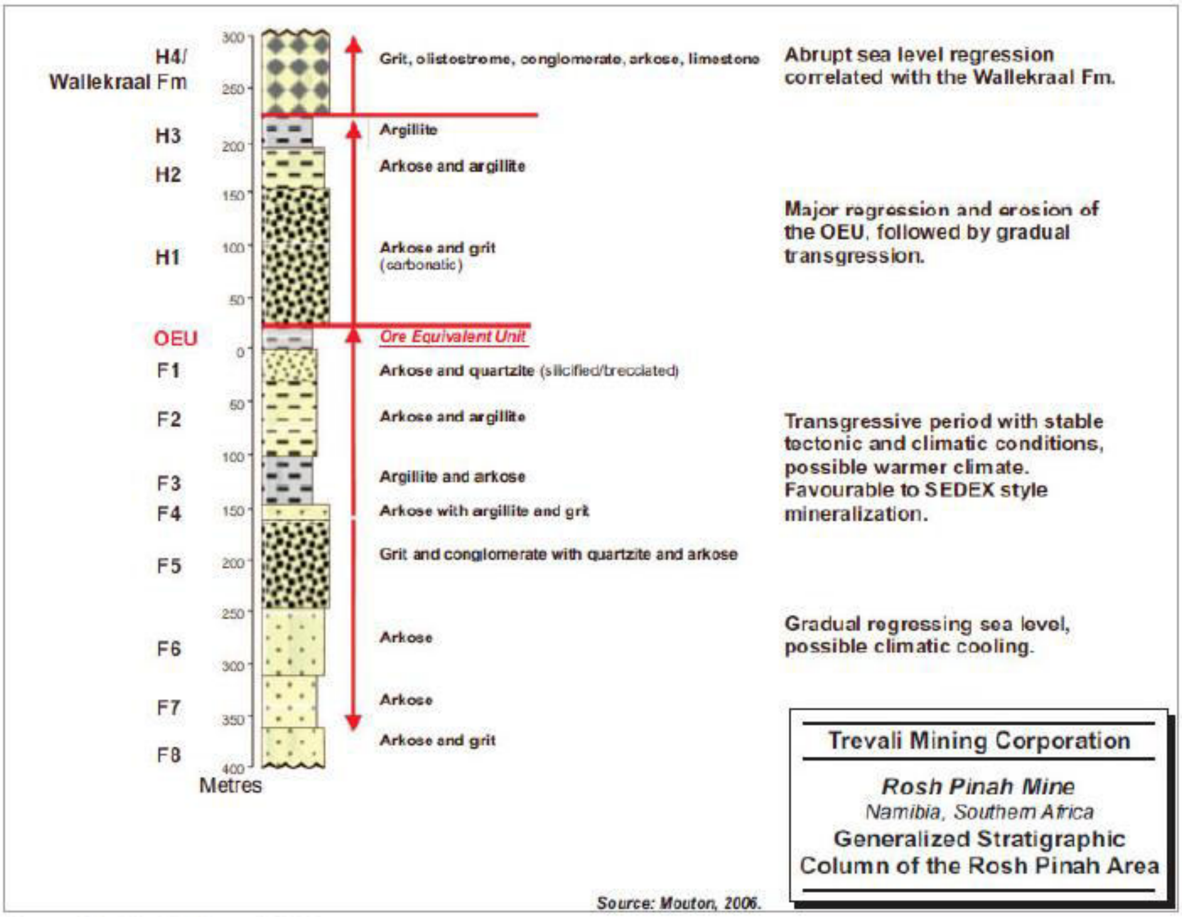
In Namibia two tectonic-stratigraphic units of the Gariep Belt exist: an eastern (Port Nolloth Zone) and a western unit (Marmora Terrane). In the eastern marginal part of the Port Nolloth Zone, volcanic-exhalative sediment-hosted (SEDEX) massive sulphide mineralisation occurs. The Rosh Pinah mine falls within this area. The geological structure of the area is very complex due to a number of historic tectonic episodes. North-west trending folds and fault systems dominate the local structure and are reflected in the topography of the area. Some of the fault systems are still seismically active and tremors (other than the underground mine blasts) are periodically felt by residents of the village.

4.3.2 Geological Setting of Rosh Pinah Mine

The Rosh Pinah deposit is hosted by the Rosh Pinah Formation (Hilda Subgroup of the Port Nolloth Group), forming part of the Neoproterozoic Gariep Terrane deposited onto a Palaeo-Mesoproterozoic basement of granite gneisses and supracrustals. The Gariep Terrane is divided into two distinct tectono-stratigraphic sub-terranes; the eastern, para-autochthonous Port Nolloth Group and the western, allochthonous Marmora Terrane.

The Base Metals Sulphides at the Rosh Pinah mine are contained within the approximately 30 m thick Ore equivalent horizon (OEH). In the Rosh Pinah mine area, the Rosh Pinah Formation has been shown to be at least 1,250 m thick as described in the Rosh Pinah Underground Mining Feasibility Study, AMC, 2021. **Figure 18** is a generalized stratigraphic column for the Rosh Pinah mine.

Figure 19 illustrates the simplified geological map.



Source: Provided by Trevali 2020.

Figure 18: Rosh Pinah - Generalized stratigraphic column.

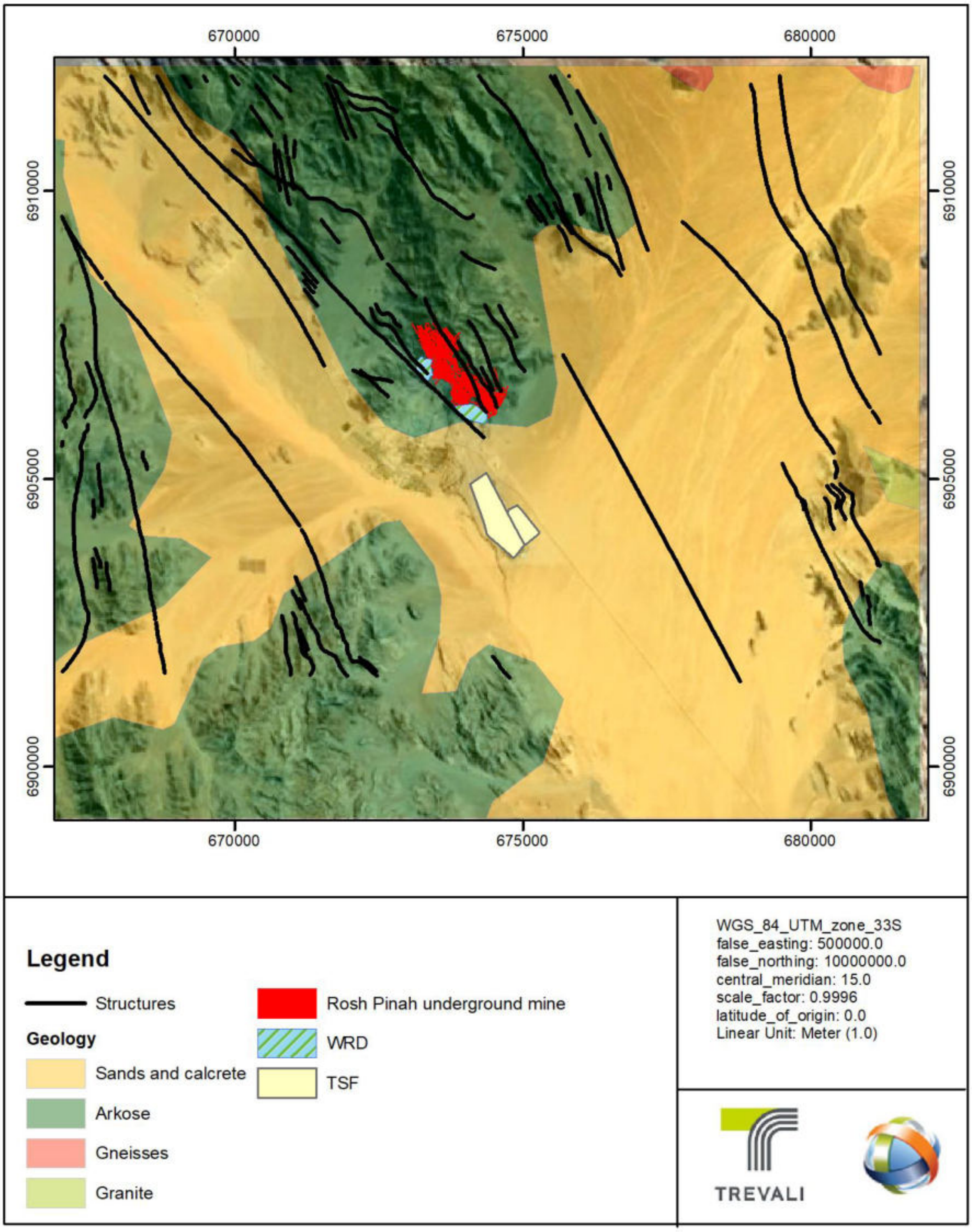


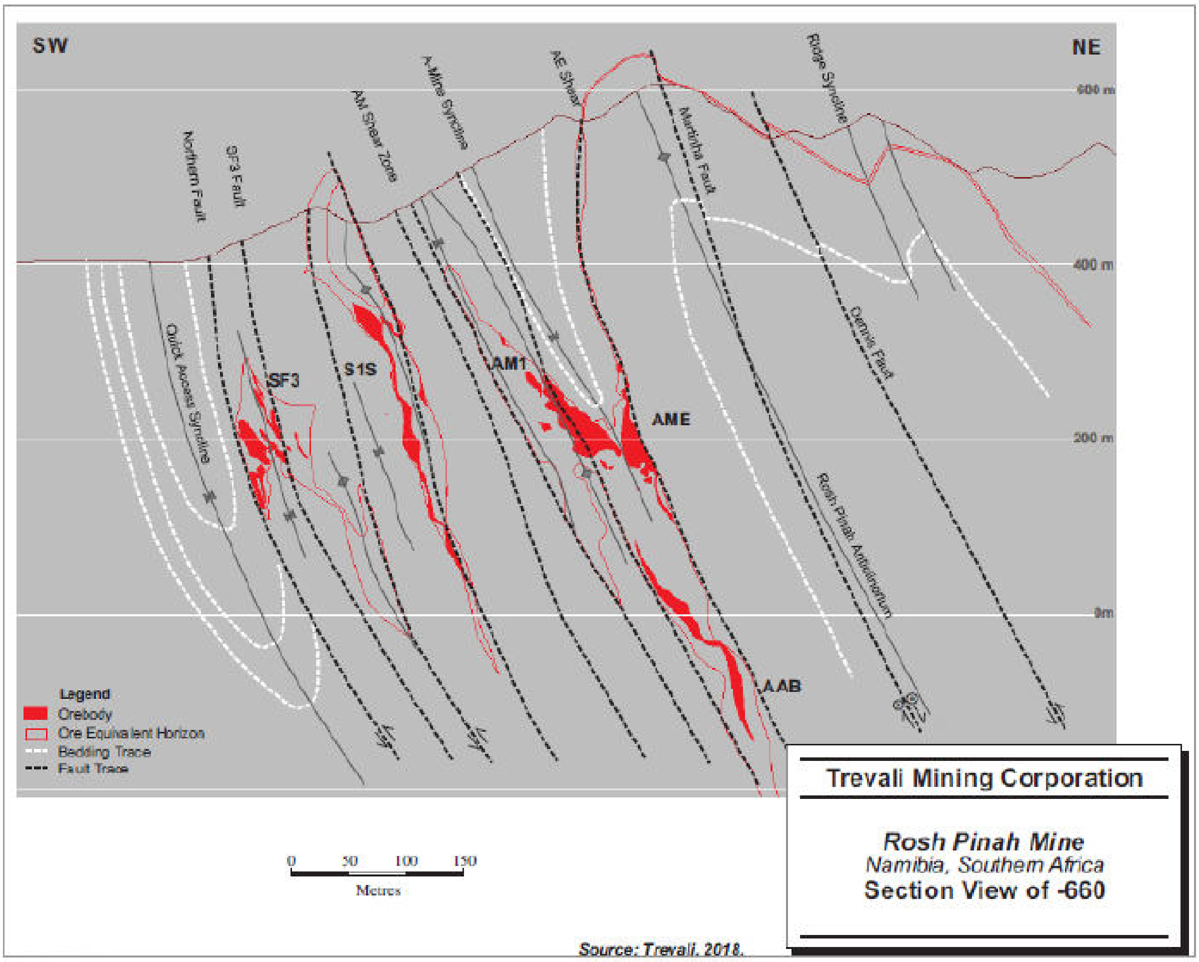
Figure 19: Rosh Pinah simplified geology

4.3.3 Structural Setting

The Rosh Pinah rock mass has been extensively folded and faulted during the continental collision.

The once flat-lying ore zone was compressed into tight isoclinal folds. Shearing, faulting, and thrusting has occurred where the limbs and hinges of these folds could not withstand the compressive stresses.

The complex structural setting at Rosh Pinah is shown in **Figure 20**.



Source: Provided by Trevali 2020.

Figure 20: Rosh Pinah structural complexity example

4.4 Soils

Due to the arid and semi-arid climatic conditions mechanical weathering predominates. This results in residual soils above the rock which are usually thin. Transported soils are predominantly aeolian sands during strong wind events or coarse colluvial talus from the surrounding mountain ranges. The soils are mainly developed on the gravel plains and in depressions/valleys, which provide some geomorphological stability (Pallett, 1995).

Desert soils are often stabilised by an organic or inorganic layer, which protects the underlying soils from erosion in areas devoid of macro-vegetation (Daneel, 1992). Soil algae and/or the inorganic surface gravel layer, usually a small pebble layer or desert pavement, protects the underlying soil from erosion. Disturbance to this fragile protective layer will result in erosion, by wind, of the soil fines, which are important for moisture retention and nutrient adherence.

Recovery from structural damage by disruption to surface micro-topography and compaction may take as long as soil formation – several thousand years (Daneel, 1992).

The soils in the Rosh Pinah area are predominately surface alluvial sediments that support mainly sparse grassland and have a low agricultural value (Rosh Pinah Landfill Study, Walmsley, 2001). Typically, the soils have a pH of ±9, high salinity and sodicity and low clay and organic-matter content (RPZC, 1999). The soils have no agricultural potential.

Although thin, the soil layer must be protected, for it is presumed to contain the valuable seedbed for the Succulent Karoo and Nama Karoo Biomes, especially since soil formation takes such a long time. Some of the plant species that are found within the Rosh Pinah Mining Licence are endemic to the area. Disturbance of the organic and inorganic protective layers can lead to increased wind and water erosion; reduced infiltration rates; reduced soil moisture content; and the inhibition of plant germination.

4.5 Groundwater

Background information regarding groundwater was obtained from the in-house report "Groundwater investigations at Rosh Pinah mine" (G. Steenekamp, Kumba Resources, 2003) and "Groundwater study and risk assessment as part of the western ore filed 3 feasibility study for Rosh Pinah Zinc Corporation" (Groundwater Complete, 2015).

4.5.1 Background of historical groundwater work at Rosh Pinah Mine

Groundwater management at Rosh Pinah was a very low-key issue until the late 1990's when deeper ore bodies were exploited and seepage rates started to increase. Specific structures such as the 'Squad Valley Fault' had especially high inflow rates when intersected by exploration boreholes or development tunnels. Such intersections significantly increased awareness of the importance of groundwater management and actions were implemented to gain a better understanding of the groundwater regime and thus the associated risks.

Table 9 provides an overview of the milestones/events taken at RPZC for groundwater monitoring and management.

Table 9: Key milestones/events in terms of groundwater monitoring and management at RPZC.

Time	Event	Actions / Recommendations
1997	High volumes and pressure groundwater influx through boreholes in WOF	• Start measuring water levels in boreholes around the mine; • Stop discharging water right outside declines; • Consider isotope tests to determine origin.
1997	Drill 7 monitoring boreholes at Tailings Storage Facility	• Start measuring groundwater levels every two weeks; • Measure water quality quarterly.
1998	Expansion of water quality monitoring program	• Measured effluent streams like EOF, WOF, Plant, Tailings discharge plus additional boreholes; • Measure water levels in open exploration boreholes;

Time	Event	Actions / Recommendations
		• Recommend measuring of groundwater inflows to mining areas.
1999	Construct first phase numerical groundwater model	• Simulate inflows and predict; • Recommend provision for additional pump capacity; • Measure water pressures in selected boreholes; • Consider drilling of boreholes around the mine for dewatering and water level monitoring; • Monitor inflows to and outflows accurately for calibration of model.
2000-2001	Rosh Pinah water project	• Minimize GW risks, optimize reuse, reduce consumption; • Included water balance compilation; • Plant water quality tolerance assessed.
2002	Follow-up numerical model	• Models updated but value limited due to gaps in flow and pressure records in space and time.
2002-2003	Drilling of additional impact monitoring boreholes	• Accurate impact quantification prompted drilling of additional monitoring boreholes; • Boreholes drilled in December 2002 at tailings, sewage ponds, rock dumps etc.; • Monthly water level and quarterly quality monitoring commenced.
2005	SAMREC code	• The SAMREC code was implemented at Rosh Pinah. This included a groundwater monitoring and risk management plan for ongoing application.
2021	SLR Namibia	• Rosh Pinah Groundwater numerical model

4.5.2 Summary of the "Groundwater investigations at Rosh Pinah mine" (G. Steenekamp, Kumba Resources, 2003)

The groundwater flow through an aquifer exists because of differences in water level or piezometric head. Generally, recharge to the aquifer is distributed fairly evenly over the land surface. Therefore, the groundwater level or piezometric head usually follows the trend of the surface topography and tends to mimic the direction of surface water run-off. On a smaller scale, inhomogeneities in the aquifer structure, like fracture zones, groundwater flow barriers and artificial discharge or recharge points, will disturb the general flow pattern, but the regional trend usually prevails. Since regional surface drainage in the Rosh Pinah area is towards the south-east, the same could be expected for groundwater. In the Rosh Pinah mining area, static groundwater (or piezometric) levels vary from 36 - 68 m below surface (mbs). However, the shallower water levels occur closer to the mountain in the topographically higher lying areas and water levels exceeding 50 mbs are measured in the plain or in the valley near the Tailings

Storage Facility. This phenomenon is explained by the difference in aquifer types, which can be divided into:

- a predominantly primary porous, medium type aquifer in the alluvial plains; and
- a secondary fractured-rock type aquifer with higher piezometric heads in the mountain and outcrop areas.

Figure 21 presents a map with the groundwater levels contoured from positions where data exists. The figure shows that although local variations and anomalies do occur, the general trend for water (or piezometric) levels is the same as the surface topography, namely in a southerly and south-easterly direction, with relatively high gradients close to the mountains and flatter gradients in the alluvial plains.

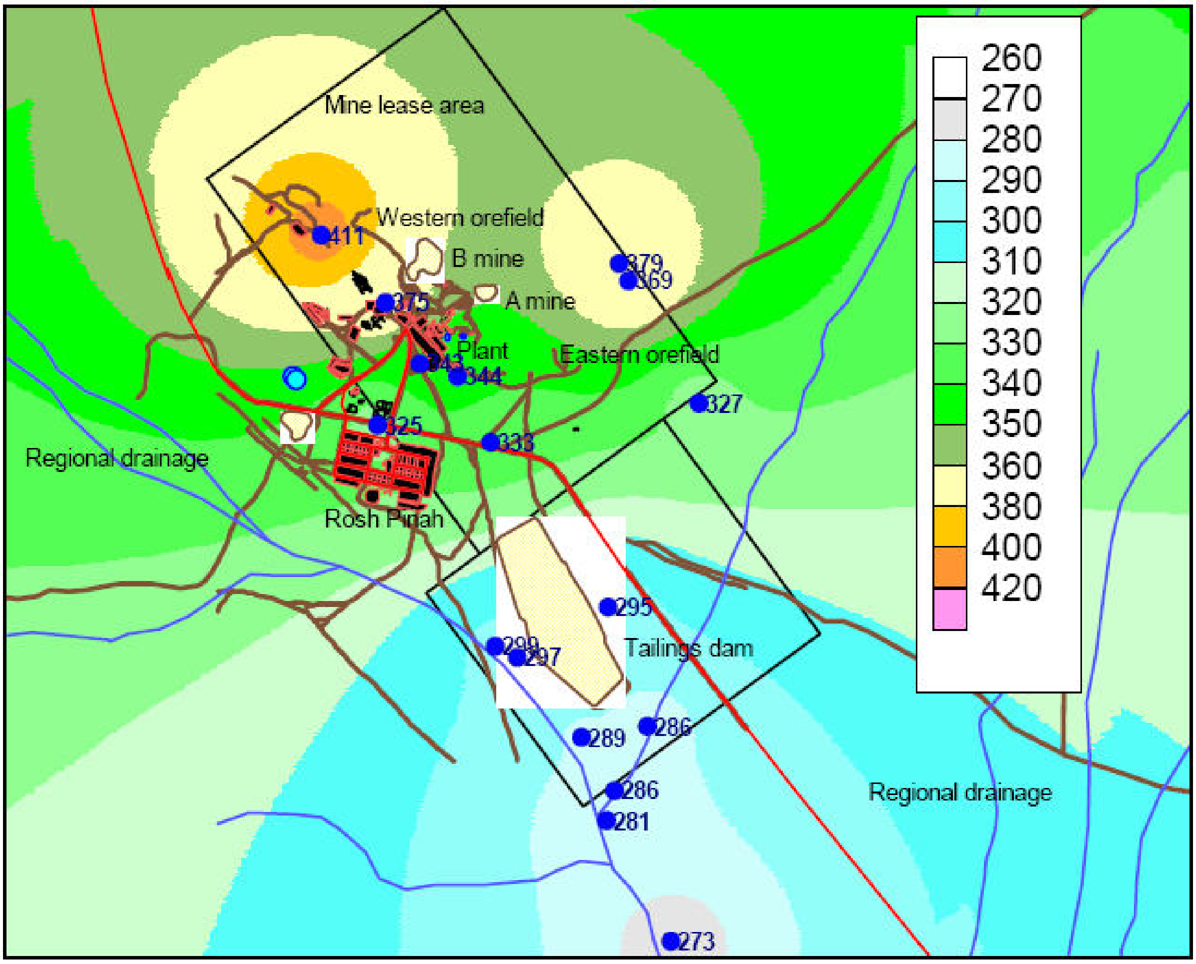


Figure 21: Groundwater level contours constructed from measured groundwater levels.

At Rosh Pinah the static water levels and piezometric heads show that two different aquifer types, namely the largely unconfined primary type aquifer and the confined fractured-rock type, exist. The mine dewatering has not affected any of the boreholes because the natural relationship of water level elevation and surface topography is a straight line for each aquifer type, and anomalous low groundwater elevations do not occur.

For Rosh Pinah only the available groundwater levels were used. The general groundwater elevation trend is evident from Figure 21 and the flow direction will be perpendicular to the contour lines, namely in a south-easterly direction on a regional scale.

4.5.2.1 Yields

Blow yields in the monitoring boreholes varied between 1 and 20 m^3/h. The highest yields occurred in the alluvial plain to the west and south of the Tailings Storage Facility, where a thick and mostly unconsolidated gravel and boulder layer occurs.

The overall success in water strikes in the fractured rock aquifer is probably attributable to the high degree of structural deformation, such as the intense folding, shearing and thrusting of the geological terrain at Rosh Pinah.

4.5.2.2 Groundwater Quality

Groundwater quality is influenced by the following factors:

- **Annual recharge** to the groundwater system

The ambient groundwater levels are relatively deep, especially in the alluvial plains where water levels are often in excess of 50 mbs. Mean annual rainfall is around 70 mm, and even if the effective recharge were as high as 5 - 10 %, the recharge would still be less than 7 mm per annum. In these conditions an old, fairly saline type groundwater is to be expected.

- **Type of bedrock** where ion exchange may impact on the hydrogeochemistry

The bedrock in the area consists of different metamorphic rock types, including carbonaceous rocks, argillites, schists, and volcanic tuffs. The impact on the hydrogeochemistry of the aquifer host rock is not expected to be significant. In the mining area itself, with the sulphide ore bodies occurring, leaching and oxidation could play a role, but not a very significant one because of the low effective recharge. In the alluvial valleys, the rock types are generally chemically inert and dissolution is not expected to have a major impact on the water quality.

- **Flow dynamics** within the aquifer(s), determining the water age etc.

Aquifer flow dynamics at Rosh Pinah will have a positive effect on the groundwater quality because the transmissivities in the aquifers are relatively high and flow can take place fairly evenly through the aquifers. The high incidence of measurable blow yields confirms that zones of high transmissivity are widespread in the mining area and that the flow system is an active and dynamic one. The low recharge is thus the main cause of poor ambient groundwater quality.

Source(s) of pollution with their associated leachates or contaminant streams:

- Tailings Storage Facility system;
- hydrocarbon sources (oils, greases, fuels and organic solvents) usually concentrated in and around workshop areas, service stations and fuel depots, but also occurring because of spillages, leaks and breakdowns in the active mining areas;
- remnants of nitrate-based explosives in mining areas as well as in the processing plant and discard dumps; and
- acid mine drainage type contamination from discard dumps, stockpiles and the processing plant area where base metals or coal are mined and processed.

4.5.2.3 Groundwater Use

Groundwater around the Rosh Pinah mining area is used for domestic purposes and livestock water supply.

Until 2001 the mine itself had used no groundwater. Since the end of 2001 groundwater influx into the underground mine – instead of being pumped out directly – has been used for drilling, dust suppression and other industrial purposes in the underground workings. The utilisation of groundwater in this way has two positive purposes:

- Water is saved and prevented from being contaminated because clean water does not have to be pumped underground where it is contaminated in the mining process.
- Risks of mine flooding are reduced because groundwater is allowed to flow freely into the mine from where it is used and then pumped out.

The groundwater flowing into the mine is very saline and has to be treated with anti-corrosion agents (PO_4 derivates) to prevent excessive corrosion on mine equipment and reticulation infrastructure.

4.5.3 Summary of the Groundwater Numerical Model, SLR Namibia (2021)

A 3-dimensional numerical groundwater model was constructed and run for the Rosh Pinah Mine, to simulate:

- Passive groundwater inflows into the underground mine as mining is progressing,
- Development of a cone of drawdown because of underground mining,
- Development and migration of a possible contaminant plume from the TSF.

The numerical model was constructed using the surface geology, the regional faults, the faults transmitted, and the detailed ore formations provided, by the mine. The geological and structural complexity in the mine area was overcome by selecting and assigning the hydrogeological units within the complex geology and structures.

The numerical model was further discretized to allow for simulation of mining. The underground working transmitted by Rosh Pinah were simplified into three main periods:

- 2021 – 2024;
- 2025 - 2029;
- 2030 – 2034.

The numerical model was run in transient mode and the underground workings were simulated as seepage face (drain nodes) activated by the time-series constructed, at the respective times when mining takes place.

The results of the numerical model indicated the development of a cone of drawdown along the faults mapped, with maximum drawdown at the end of mining (year 2034, **Figure 22**).

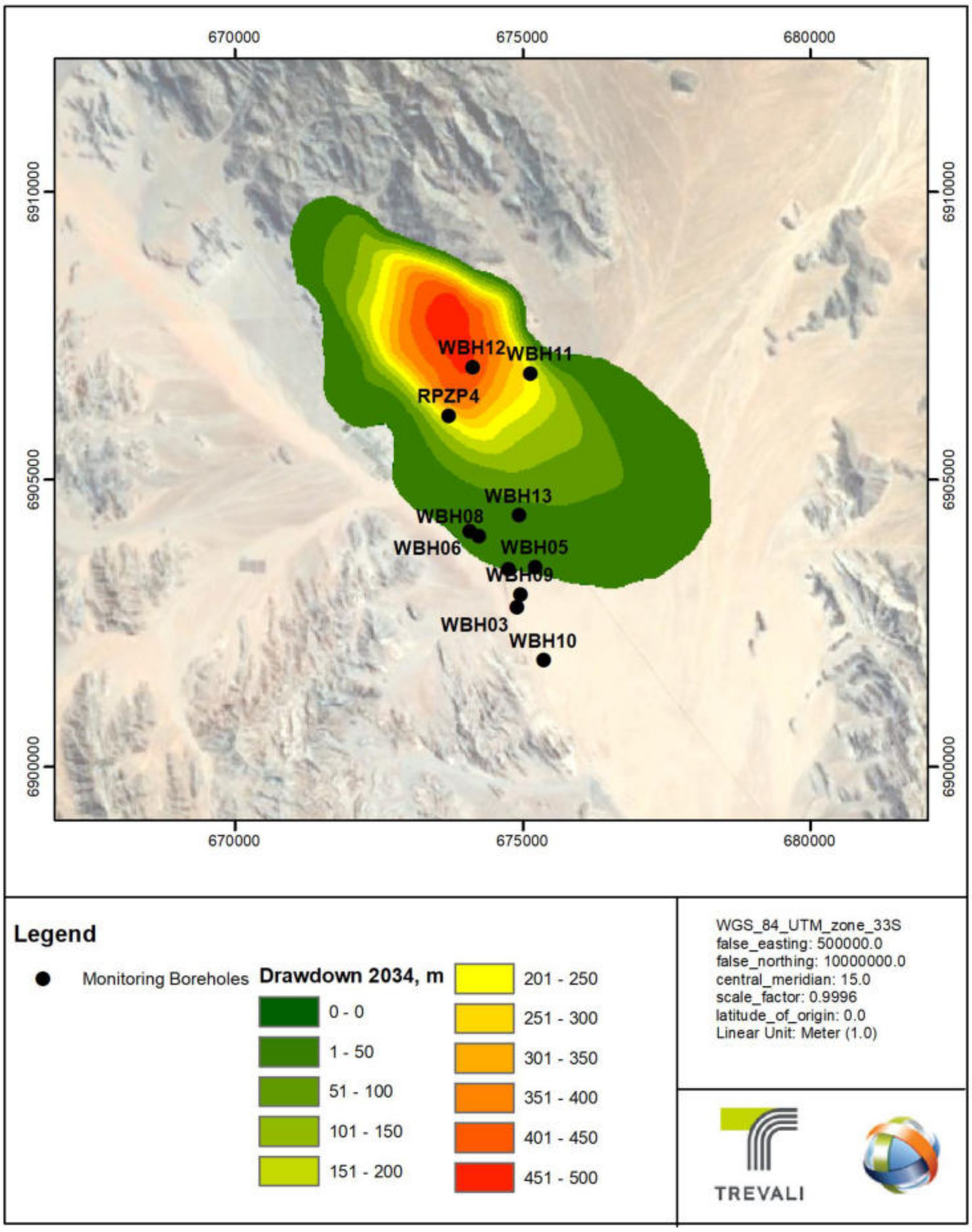


Figure 22: Groundwater level drawdown at year 2034 (end of mining).

The seepage face nodes (mining nodes) were switched-off after the end of mining period and the water levels started to recover. **Figure 23** shows the distribution of the hydraulic head at the end of the simulation, (year 2120), indicating a 30 m residual drawdown. This is attributed to low recharge in the area.

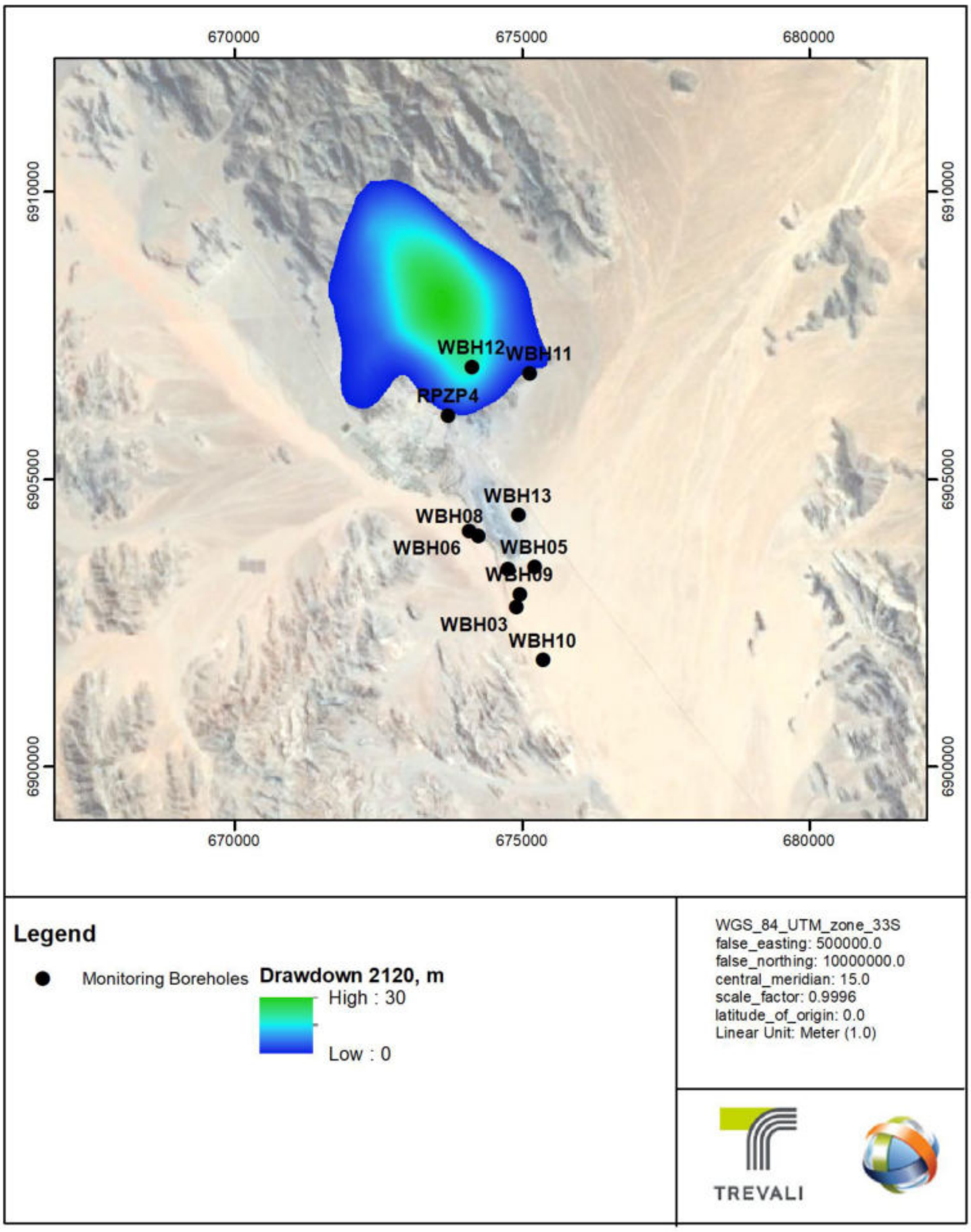


Figure 23: Groundwater level drawdown at year 2120 (end of simulation).

The theoretical predicted groundwater passive inflows into the underground works are shown in **Figure 24**. However, as stated above, these are theoretical inflows predictions, calculated by the model and considering that there will be no losses, spillages or infiltration. The "practical" inflow rates should be looked at as realistic volumes which could be pumped out from the underground workings, and these are influenced by several factors:

- The underground workings are very large in size (effective length and area),
- Seepages and infiltrations back into the formations and not captured into the underground sumps'
- Underground water losses along the galleries'
- Underground water losses due to ventilation.

It is estimated that the losses into the underground can account to approximately 2/3 of the theoretical inflow rates. Taking these into consideration, the realistic groundwater inflow which will pumped out (net) from the underground will be as shown in **Figure 25**.

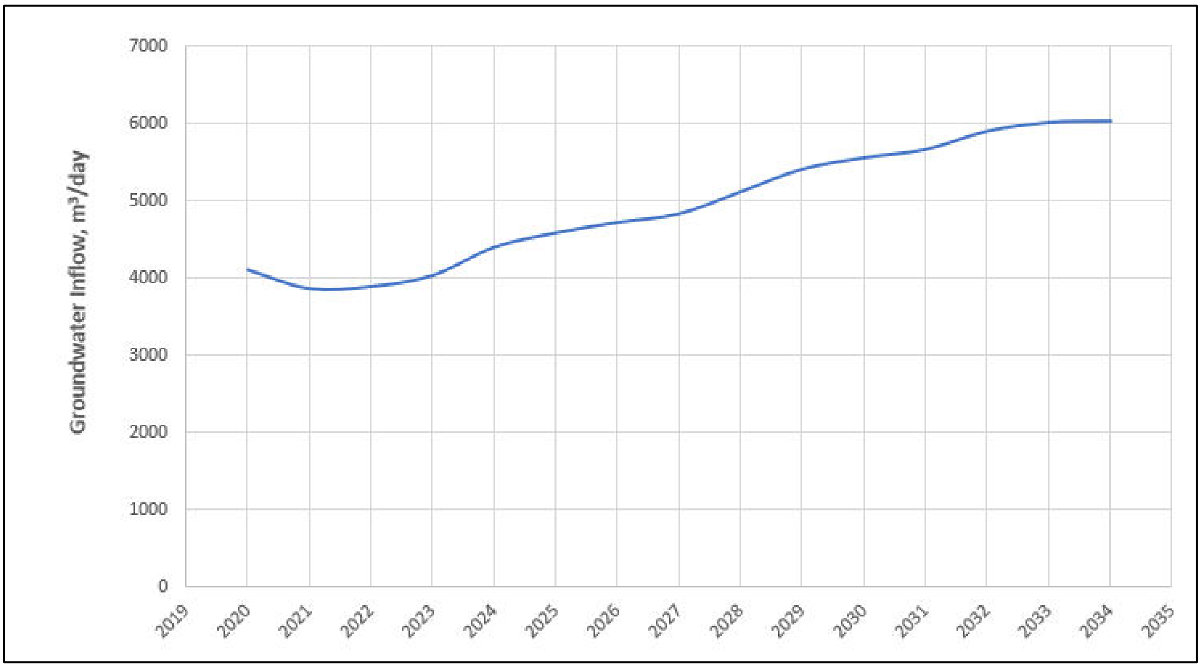


Figure 24: Predicted theoretical groundwater inflows into mine workings for Life of Mine.

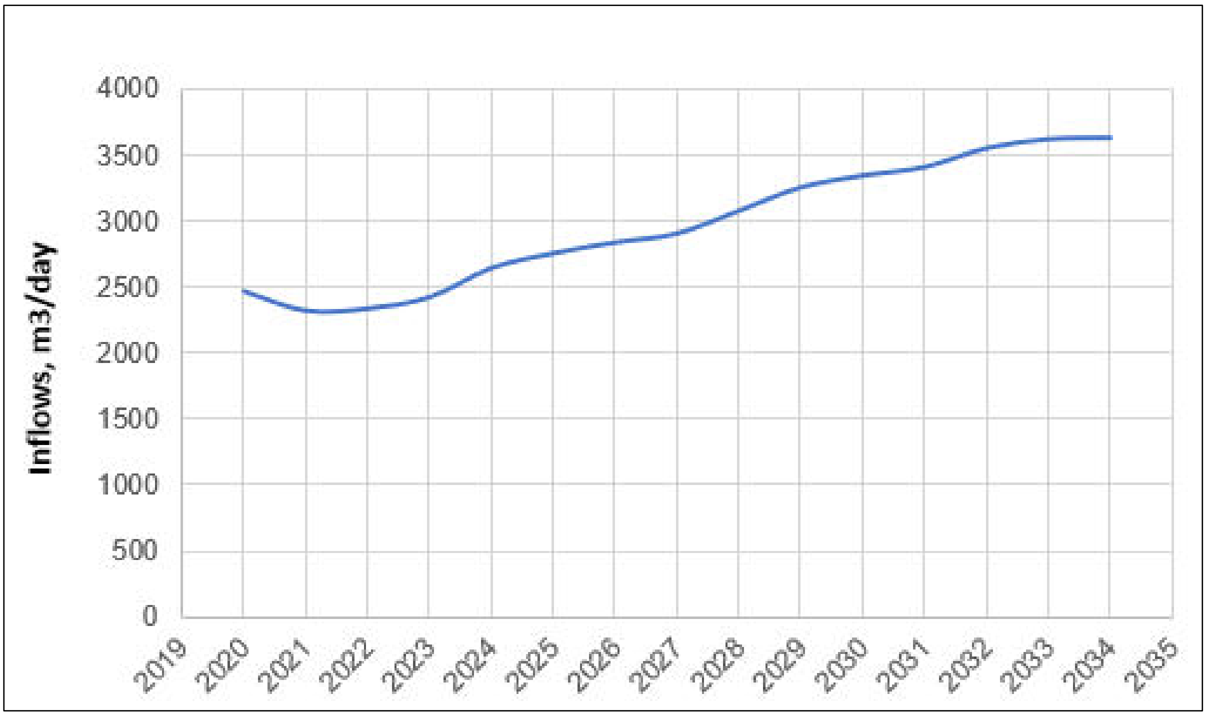


Figure 25: Predicted practical groundwater inflows into mine workings for Life of Mine.

Maximum practical inflow of approximately 3600 m^3/day, occurs at the end of year 2034 (end of mining) when the underground is at maximum development.

The source term for the TSF and TSF expansion indicated that there are no real constituents of concern in the leachate and the ARD potential is low. The various elements concentrations determined by the Source Term Study do not indicate exceedance. The contaminant plume migration was evaluated in terms of percentages, with the 100% of source term on the footprint of the waste facilities.

Figure 26 shows the maximum extent of a contaminant plume, at the end of the simulation (year 2120), in % units of any given concentration.

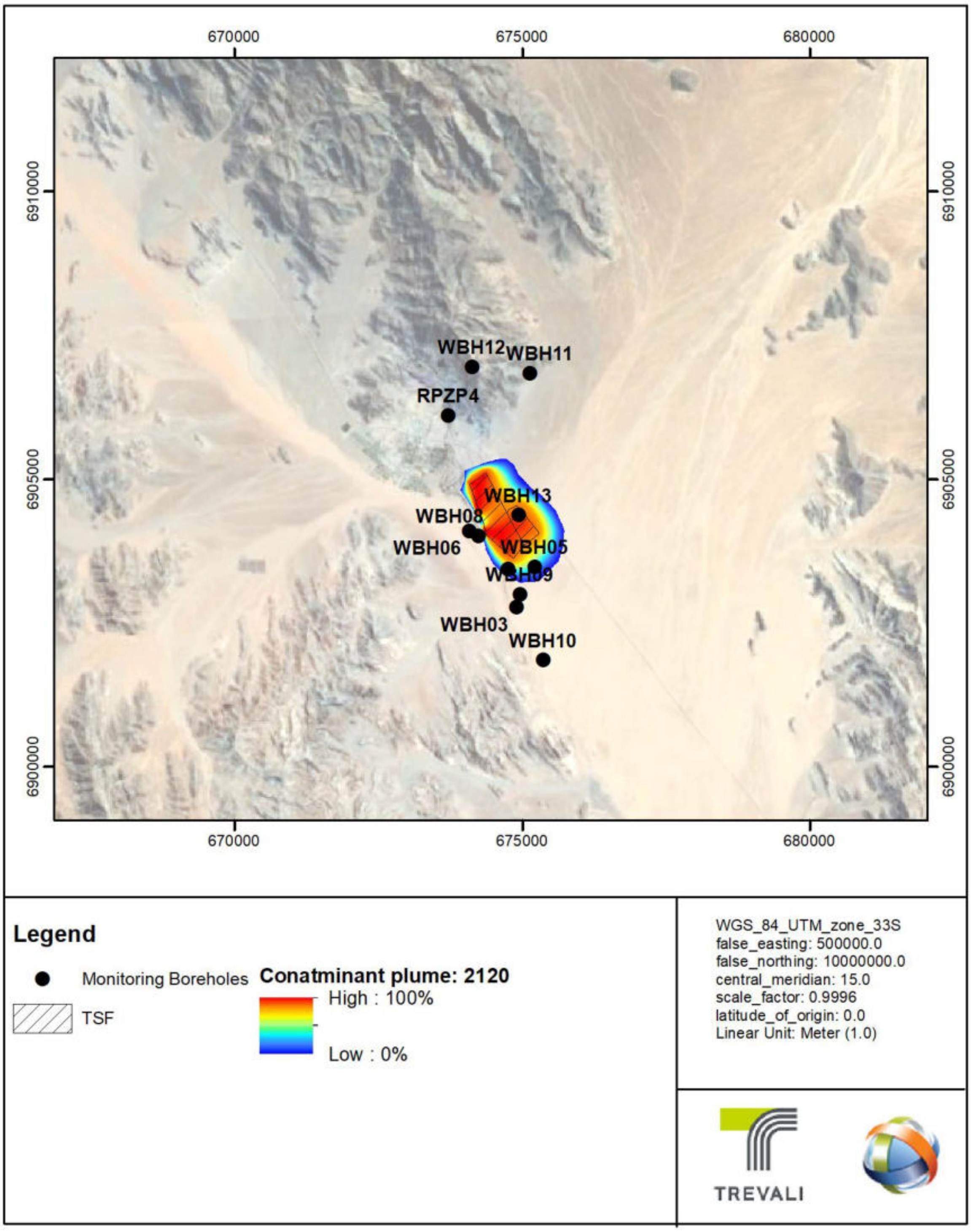


Figure 26: Predicted contaminant plume at the end of the simulation.

4.6 Flora

Information about Flora within the Rosh Pinah area was obtained using information gathered by researchers from the National Botanical Research Institute (NBRI), especially from Ms C. Mannheimer who visited the area in November 2002; and the Botanical Input Study to the Rosh Pinah Landfill Selection Study (WSP Walmsley, 2001), conducted by Dr. A. Burke (October 2001). C. Mannheimer conducted further work in the Rosh Pinah area during the 'EIA for the proposed NamWater Pipeline form the Orange River take in to RPZC Mine' (ASEC, 2013) and the 'EIA for the new NamPower power line form Obib to Zincum substation for RPZC Mine' (ASEC, 2013). A brief summary of the flora is provided below.

Although it has some floral affinities with the Nama-Karoo, the project area falls within the Succulent Karoo Biome, which is regarded as a global hotspot of biological diversity (Myers et al. 2000), including both plants and animals, and is extremely sensitive in terms of near-endemic, endemic and protected plant and animal species. It is important in global as well as regional and national terms. This makes only absolutely unavoidable damage acceptable.

Approximately 17% of the Namibian flora as a whole is thought to consist of endemic species (Barnard 1998), and over 30% of plants that occur in the Namibian section of the Desert Biome are believed to be endemic to that area. This is a remarkably high figure, and the areas of highest plant endemicity in the Namib are the Kaokoveld and the southern Namib, both regarded as major centres of endemicity in Namibia (Maggs et al. 1998). Furthermore, recent assessment by Burke and Mannheimer (2004) indicated that the Sperrgebiet (which excludes Aus) carries nearly 25% of the plant species known to occur in Namibia, making it a national biodiversity hotspot. Elevated areas such as mountains and koppies are known to harbour many species of conservation concern, making them sensitive to environmental disturbance, some more than others. In addition to on-site damage the creation of obvious access roads promotes illegal access and plant removal by criminal collectors, and is of particular concern as it perpetuates and aggravates existing damage ad infinitum. An additional concern of great importance is the negative visual impact of roads and other infrastructure. This factor is of particular importance in an area such as the southern Namib, where open and relatively unspoilt vistas may be regarded as a major tourist attraction that will provide long-term income to the country. Although the proposed route lies outside the Sperrgebiet it still harbours many of the same species of conservation concern.

The RP2.0 Expansion Project only will be constructed within the existing ML 39 area and no virgin areas will be affected.

4.7 Fauna

No specialist study focusing on the Rosh Pinah area specifically was conducted. Associated with the unique vegetation habitats around the Rosh Pinah area are a large number of animal species which are of conservation importance or endemic to the region. The Nama Karoo Biome supports 131 desert vertebrates. Of this total, 16 species (nine reptiles, five mammals, two birds) are endemic to the biome (Lovegrove, 1993). The Succulent Karoo Biome has 88 desert vertebrates, of which 25 occur nowhere else. There are nine endemic reptiles in the Nama Karoo Biome.

The RP2.0 Expansion Project only will be constructed within the existing ML 39 area and no virgin areas will be affected.

4.8 Archaeology

Dr. Kinahan conducted various specialist studies within the Rosh Pinah/Skorpion area.

In 2001 he conducted the archaeology specialist study for the Rosh Pinah Landfill Site Selection Study (WSP Walmsley, 2001). General research in areas of southern Namibia has revealed evidence of intermittent human occupation over approximately the past half million years (Kinahan, 2001, in: Rosh Pinah Landfill Site Selection Study). The findings include surface and buried stone artefacts, pottery, osteological remains, rock shelters, and possible stone grave cairns. Semi-nomadic pastoralists apparently occupied the area near the Skorpion Zinc Project in the late 1400s and evidence of their activities is found in the remains of portable mat house encampments (Kinahan, 2001, Noli 1999). The archaeological assessment for Skorpion Zinc determined that a significant number of the sites studied in the project area are associated with rocky outcrops (Kinahan, 2001).

He conducted further work in the Rosh Pinah area during the 'EIA for the proposed NamWater Pipeline form the Orange River take in to RPZC Mine' (ASEC, 2013) and the 'EIA for the new NamPower power line form Obib to Zincum substation for RPZC Mine' (ASEC, 2013).

However, the RP2.0 Expansion Project only will be constructed within the existing ML 39 area and no virgin areas will be affected.

4.9 Socio-Economic Environment

4.9.1 The //Kharas Region Overview

<u>Demographics</u>

Rosh Pinah is situated 376 kilometres south west of Keetmanshoop in the //Kharas Region, which is the largest of Namibia's regions (161,086 km^2). It is the most arid region and has the lowest population density of 0.5 people per square kilometre. The region's population is estimated to be 89,000 (about 3.7% of the national population) of which just under one third (31%) of is under the age of 15 years (NSA, 2019).

The population is predominantly urban with 72.6% living in urban areas. The average size of household size has decreased to 3.6 in 2015/16 from 4.2 in 2011. Two thirds of households (66%) are headed by males (NSA, 2016).

In-migration to the //Kharas Region over decades has been greatly influenced by mining, irrigation, fishing and industrial type developments but this has slowed in recent years and only about 13% of the population was born in the region at the last census in 2011 (NSA, 2013, p. 45). In 2011, three main languages were spoken in the //Kharas Region and these are: Afrikaans (36%), Oshiwambo (27%), and Nama/Damara (23%) (NSA, 2013, p. 12).

<u>Economic Profile</u>

The economy of the //Kharas Region is essentially driven by the mining industry (diamonds at Oranjemund and along the coast up to Lüderitz as well as zinc and lead at Rosh Pinah), commercial agriculture (livestock farming predominantly to the east, as well as irrigation farming at Naute Dam and along the Orange River), a large non-tradable sector (government services) and by tourism (MLR, 2011). The region has much to offer tourism such as the Tsau //Khaeb National Park (formally the Sperrgebiet), the Fish River Canyon and the Namib-Naukluft Park.

Both RPZC and the Skorpion Mine have a huge impact on the regional economy with the import of chemicals for ore processing and the export of zinc and lead through the expanded Port of Lüderitz. At national level, the export-oriented production of the mines contributes significantly to the country's foreign currency earnings, as well as direct and indirect taxes paid by the mines and their employees.

In terms of employment, key industries in the //Kharas Region were: private and public service (43%), agriculture, hunting, forestry and fishing (32%), mining and quarrying (9%) and manufacturing (6%) (NSA, 2013).

The main source of income in the //Kharas Region in 2015/16 was: salaries and wages (79%), pensions (9%) and remittances/grants (5%), while less than 2% of households relied on either subsistence and commercial farming or business (NSA, 2016).

Results from the 2018 Namibia Labour Force Survey indicate that the Labour Force Participation Rate (the number of persons in the labour force given as a percentage of the working age population in that population group) for the //Kharas Region is 74% (which is a slightly higher percentage than the national rate of 71%). Males have a significantly higher employment absorption rate of 55% compare to women (45%) (NSA, 2019, p. 58).

The broad unemployment rate (i.e. people being without work, or who are available for work, irrespective of whether they are actively seeking work) for the Kharas Region is 32% which is only slightly lower than the country as a whole (33%). This is a significant regional increase from 24% in 2012 (NSA, 2013). Women in //Kharas suffer a higher unemployment rate than men (35% to 29%) (NSA, 2019, p. 80). Youth aged 15- 34 years who are not in employment and not in education or training are in a worse situation affecting 46% of women and 35% of young men (NSA, 2019, p. 90).

Poverty Levels

According to the 2015/16 NHIES, the //Kharas Region has an average household income of N$116, 875 and an average income per capita of N$32,760 (which is slightly below the national average of N$119,000 per household and above the average income of N$28,400 per capita.

The number of poor and severely poor people[1] in all regions has been dropping significantly since independence in 1990. Nationally, the NHIES 2015/16 survey found that overall poverty levels have reduced significantly from 37.7% in 2003/4 to 17.4% in 2015/16 although the inequality in income distribution (Gini Index) remains high at 56%. People in //Kharas Region experience lower levels of poverty or severe poverty compared to many other regions in Namibia (**Figure 27**).

[1] Severely poor is defined as spending N$389.3 per adult per month on basic necessities, whilst an adult classified as poor spends N$520.80 per month on basic necessities.

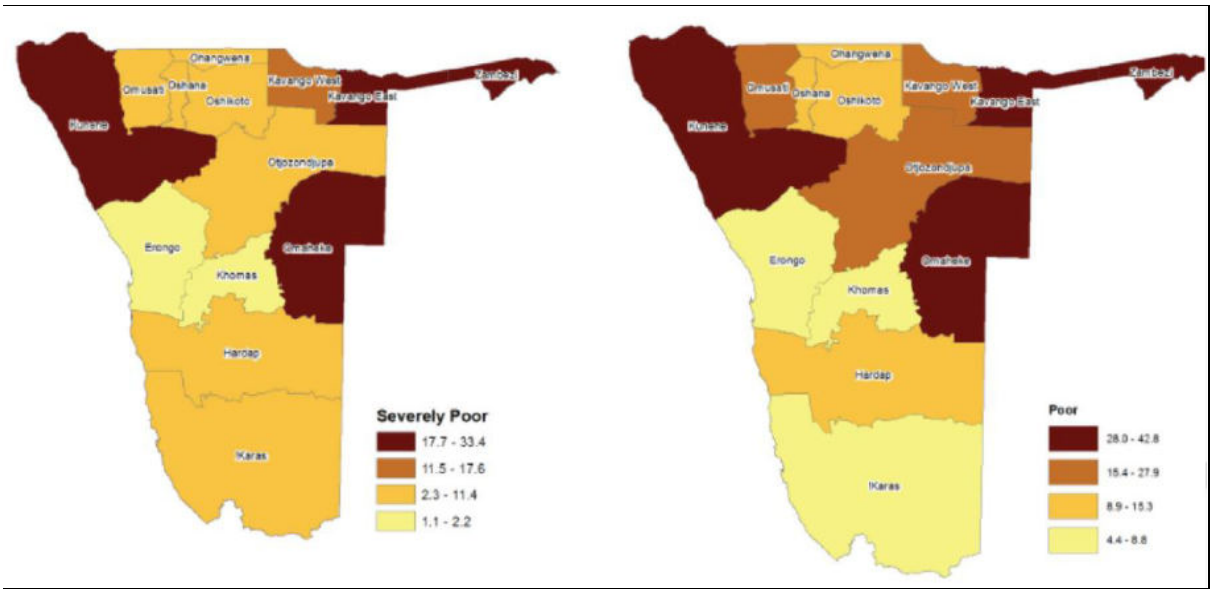


Figure 27: *Regional comparison of the distribution of poverty in 2015/16. (*Source: (NSA, 2016, p. 107)

4.9.2 Health and Education

//Kharas residents are generally healthy with over 86% of the population reporting they have no chronic illnesses (NSA, 2016, p. 74). The most common disease was high blood pressure suffered by 8% of the population.

Literacy rates among all men and women over the age of 15 years are similar at 95% while this increases to over 98% among the age group 15 – 24 years (NSA, 2016, p. 68).

Over the last five years, the government has increased the number of schools, classrooms and qualified teachers in response to the growing number of learners. There were over 22,000 learners from Grade 0 to Grade 12 in schools in the region at the beginning of 2017, of which 27% were in secondary school (Grade 8-12). However, there is a disturbing trend that teachers with teaching qualifications have dropped from 93% in 2012 to 80% in 2017.

4.9.3 Rosh Pinah

The town of Rosh Pinah came into being in 1968 when the first major mining operation, Rosh Pinah Zinc Corporation (RPZC) was set up in the area. When Skorpion Zinc mine and zinc extraction/ production plant opened in 2003, Rosh Pinah's population continued to increase rapidly.

The Skorpion Zinc mine is currently in care and maintenance with plans to re-open. In 2017, the Skorpion Zinc workforce was reduced by over 340 workers which already impacted the local economy (CoM, 2018) and (CoM, 2019).

Rosh Pinah is not a proclaimed town and does not have a municipality. The town is under the control of the two mines, RPZC and Skorpion Zinc, who manage the town via RoshSkor Township (Pty) Ltd. There are a lot of stakeholders involved in the process to transfer the town to Government, which is the main driver of the process. As of last year, it was agreed to embark on a sustainability plan for the town[2].

The land on which Rosh Pinah is situated falls within the two mines' accessory works area – land made available by Government for a mine to develop accommodation and other facilities to improve the quality of life of their employees.

One of the main challenges faced by the town is access to freehold land. Currently private individuals have the opportunity to acquire the right to lease a piece of land. This is done contractually, giving an individual the first right to purchase the land after proclamation. This right is also transferrable. Apart from the right to freehold land, Rosh Pinah offers all other benefits and drawbacks of a small town. RoshSkor does not charge rates but it charges services fees for electricity and other services.

By December 2017, the population was estimated to be 7,400 living in 1216 households in the informal settlement of Tutungeni and 1085 households in the formal town[3]. Over the last 5 years, no new erven have been developed.

Tutungeni

Information in this section is from the household survey conducted by RoshSkor at the end of 2017 (RoshSkor, 2018). Approximately 3,800 people live in Tutungeni in about 1,200 households. The majority of Tutungeni residents are Oshiwambo speaking people (59%), followed by Rukwangali speaking households (21%). Nama/Damara is spoken in about 11% of households, and fewer households speak Afrikaans, OtjiHerero, SiLozi and English as their home language. The majority of residents are adults (58%) and all are literate. All children of school-going age are in school.

In 2017, three quarters of Tutungeni households (77%) live in their own structures and have signed lease agreements enabling them to stay on the erf. The remainder (23%) rented houses belonging to other people. An issue for RoshSkor is that 22% of households are not up to date with their service fees for electricity and water; some debts were incurred by earlier tenants which have prevented the plots being transferred into the current occupier's names. **Figure 28** Shows the Tutungeni settlement.

[2] Pers. comm. Ronnie Slabbert, Town Manager, RoshSkor, September 2019

[3] As above.

Figure 28: Photo of Tutungeni settlement. Source: (RoshSkor, 2018)

76% of the households surveyed in Tutungeni stated that they earn a monthly income of N$5,500 or less, while 17% declared they did not have an income.

Business diversification is limited. Of the 95 businesses registered in the 2017 survey, 70 were shebeens and liquor outlets while 13 rented flats and the rest were hair salons, barbers shops and mini-markets. In addition, there are 16 informal traders at the informal trading market and approximately another 6 which are trading at a local shopping complex[4].

Rosh Pinah receives services delivered by institutions like Telecom, Namibian Police, Immigration, NamWater, NamPower, NamCol and NamPost.

Education and skills development

Rosh Pinah has a government primary school, Hoeksteen Primary, which provides education from Grade 0 – 7 and the Government's Tsau//Khaeb Secondary School which offers Grade 8 – 12. The Rosh Pinah Academy is a private school with 75 learners from Grade 1 -7.

The Hoeksteen primary school has 1,075 learners from aged 5 to 13. The school ranked third best in the region in the Standardised Achievement Tests taken at Grade 5 and Grade 7 in 2018. One of the major challenges is that the school only receives N$150 per learner for textbooks, readers, stationery and school cleaning materials from the government per year. As this does not even cover the cost of one textbook, the school organises sports and fun events to raise funds. In terms of physical infrastructure, the school is in need of 2 additional classrooms and a library with storeroom and accommodation for teachers with families[5].

Tsau//Khaeb opened in 2016 on erven donated by Skorpion mine. It currently has 341 learners in 17 classes. It was ranked the fifth best performing school in the //Kharas Region in 2018 for Higher Level Grade 12 and for Grade 10 and over 50% of the leavers went on to tertiary

[4] Pers. comm. Ronnie Slabbert, Town Manager, RoshSkor, 30/9/2019

[5] Pers Comm: Ms Kauri, Principal, Hoeksteen Primary School on 8/10/2019

education at Namibian Institution of Mining and Technology (NIMT), the University of Namibia (UNAM) or the Namibia University of Science and Technology (NUST). The school's main challenges are the shortage of textbooks, so learners have to share 2-3 learners per textbook; it is two classrooms short and needs a science laboratory. RPZC is represented on the school board and provides accommodation for some teachers and sponsors some annual sports and achievement awards' events[6].

The Rosh Pinah Academy follows the government curriculum but it no longer receives a government subsidy. The school has suffered from a drop in learners partly as fees have had to increase but also as Skorpion mine has reduced its workforce[7].

Both mines offer bursaries for Namibian students and also offer opportunities for employees to gain further skills training. Other social responsibility contributions in the region include support to (NIMT) Keetmanshoop and the OBIB Training Centre in Rosh Pinah.

Health

Rosh Pinah has a state clinic staffed by two nurses and two community counsellors which provides health care to approximately 80-90 people per day; a doctor visits twice monthly. There is also a private healthcare company, Life Employment Health Solutions, which runs Sidadi clinic in town, staffed by 2 doctors, 6 nurses and other para-medics which provides health care to mine employees and the general public.

RPZC supports the running of a day care centre for 50 orphans and vulnerable children at the Centre for Hope where the children receive a daily meal and help with their homework.

Business and Development

A range of businesses cater for most of the community's needs. However, all infrastructure and most of the buildings and recreational facilities belong to the mines. Small and medium enterprises are dependent on the support of the residents; tourism is still limited.

RoshSkor is continuously involved with the implementation and support of SMEs through both mine's social investment programmes. A primary asset is water from the Orange River, approximately 30km away from the town, but increased electricity prices and long distances from potential markets, jeopardize agriculture projects. In an attempt to compensate for limited industrial potential, a lot of effort is put into skills development.

The OBIB Training Centre facilitates sponsor-driven training which can provide basic skills on which to start income generating activities such as nail-painting and beadwork. It has two production workshops which employ five leather workers and five weavers. RPZC is the major sponsor of these two projects as they are not sustainable.

[6] Pers Comm: Ms Nanyemba, Principal, Tsau//Khaeb Secondary School on 3/10/2019

[7] Pers Comm: Mr Farmer, Principal, Rosh Pinah Academy on 3/10/2019

5 ENVIRONMENTAL MONITORING AND MANAGEMENT PROCEDURES AT ROSH PINAH MINE

5.1 Groundwater Monitoring within the Mine Area and the TSF

RPZC Mine has a total of 13 monitoring water boreholes within and around the mine facilities (see **Figure 29**). Since 1997 the monitoring system is in place, and all monitoring boreholes are sampled quarterly and analysed by NamWater in Windhoek. Samples are analysed for zinc (Zn), lead (Pb), copper (Cu), arsenic (AS), cadmium (Cd) and cyanide (CN). The groundwater quality is reported in comparison with the ‘Requirements for the purification of wastewater effluent’ – General Standards, Water Act of 1956 (Act 54 of 1956). Water levels are very constant in the region, staying within 40 to 60m below surface for all measured boreholes. Water depths in the boreholes are taken every 2 weeks.

WBH13 is no longer a valid sampling point since construction of the tailings dam extension started end of 2021.

Table 11 provides the maximum concentration in milligrams per liter ‘Requirements for the purification of wastewater effluent’ (Act 54 of 1956)), while shows the results from 2019 to 2022.

Table 10: Maximum concentration in milligrams per liter 'Requirements for the purification of wastewater effluent' (Act 54 of 1956)).

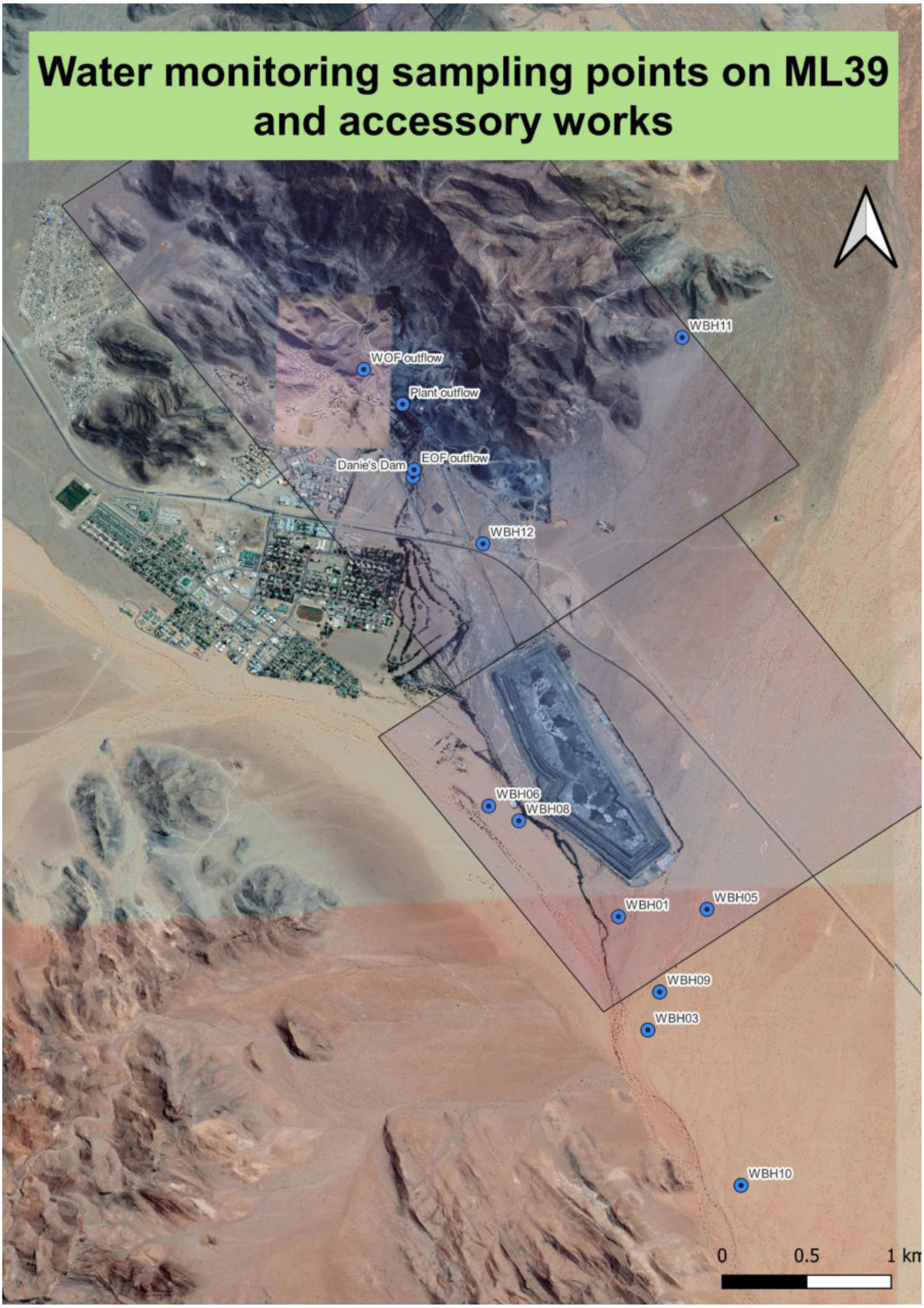
Element	Permitted max. concentration in milligrams per liter
Zn	5.0
Pb	0.1
Cu	1.0
AS*	0.5
Cd	0.1
CN	0.5

*(0.01mg/l in drinking water – WHO)

Table 11: Monitoring boreholes in which one of the elements analysed exceeded the maximum concentration (2019 and 2022).

	2019				2020			
Elements	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**
Zn	none	none	no data available	none	no data available due to Covid19 pandemic	none	none	none
Pb	none	WBH12		WBH12, water return dam		none	none	WBH 13, water return dam
Cu	none	RPZ4		none		none	none	none
As	none	none		none		none	none	none
Cd	none	plant outflow, tailings returned		none		none	none	none
CN	plant flow out, tailings return	plant outflow		none		none	none	none
	2021				**2022**			
Elements	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**
Zn	no data available due to Covid19 pandemic	none	Danies dam	none	WOF outflow	none		none
Pb		WBH05, WBH08, WBH09, WBH11, WBH13, WBH12, Danie's dam, tailings return	WBH12	WBH12, Danies dam, EOF outflow, Plant outflow	Danies dam, EOF outflow	none	Danies dam, EOF outflow	Danies dam and EOF outflow
Cu		none	none	none	none	none	none	none
As		none	none	none	none	none	none	none
Cd		none	none	none	none	none	none	none
CN		tailings return	none	none	none	none	none	tailings return dam

Figure 29: Monitoring boreholes within the mine and the TSF.



5.2 Dust Monitoring

Since August 2006 Fraser Alexander carries out a dust monitoring programme. Sixteen dustfall monitoring stations are positioned around Rosh Pinah Town, Rosh Pinah Zinc Corporation Mining Site and the Tailings Facility, as well as Tutungeni and a background station approximately 3km south of the TSF. Twelve of these stations measure only total dustfall, and these are managed and sampled by Fraser Alexander. Seven of the stations are directional and managed by RPZC. Three stations have both a directional and total fallout bucket. (see **Figure 30**).

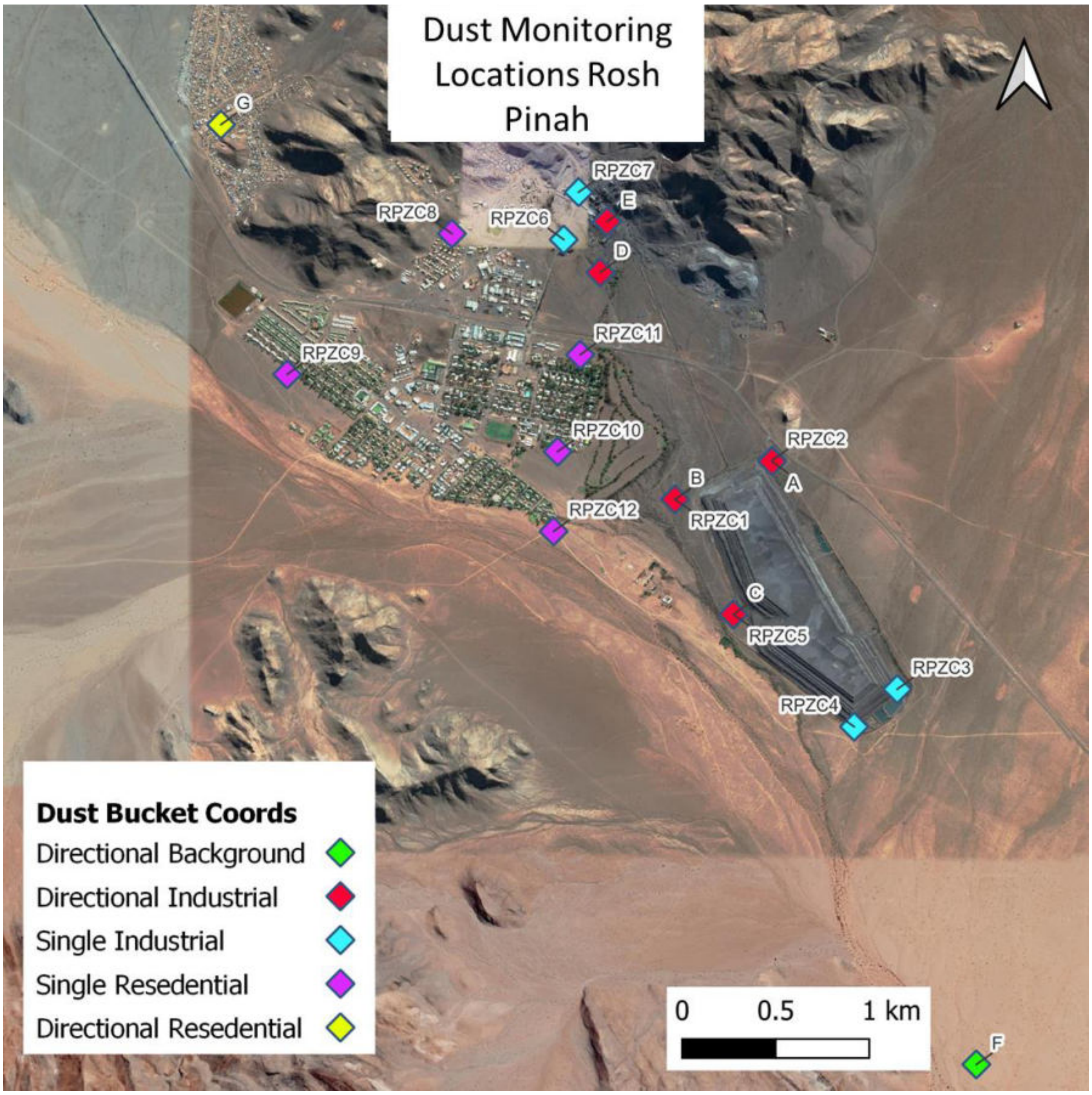


Figure 30: Dust monitoring sample point locations. (Source: RPZC SPI).

The Environmental Section of Rosh Rinah Mine have also installed directional dust bucket around the tailings dam to further enhance the dust fallout programme to wind direction influences.

According to SABS standards the following classification regarding concentration levels for dust are applicable:

0 – 600 mg/m²/day:	RESIDENTIAL LEVEL - Permissible for residential & light commercial areas
600 – 1 200 mg/m²/day:	INDUSTRIAL LEVEL - Permissible for heavy industrial areas
1 200 – 2 400 mg/m²/day:	ACTION LEVEL - Investigation required immediately
Above 2 400 mg/m²/day:	ALERT LEVEL - Action required immediately

Figure **31** and

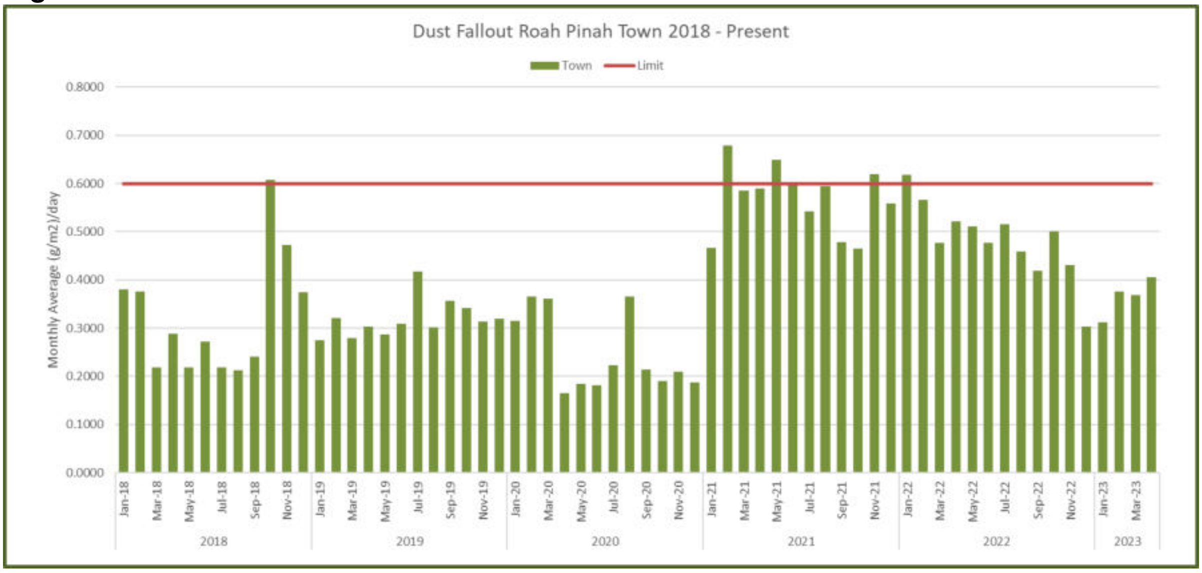


Figure 32 provides the results of the dust monitoring programme (March 2018 – March 2023), source: RPZC Monthly Environmental Reporting).

The last recorded exceedance regarding the village monitoring, occurred beginning of 2021 through a combination of abnormal wind conditions and operational events. It is observed that the dust suppression measure instituted at the TSF (see mitigation measures below) have yielded positive results referring to the reduction in dust fallout levels starting February 2018 to date.

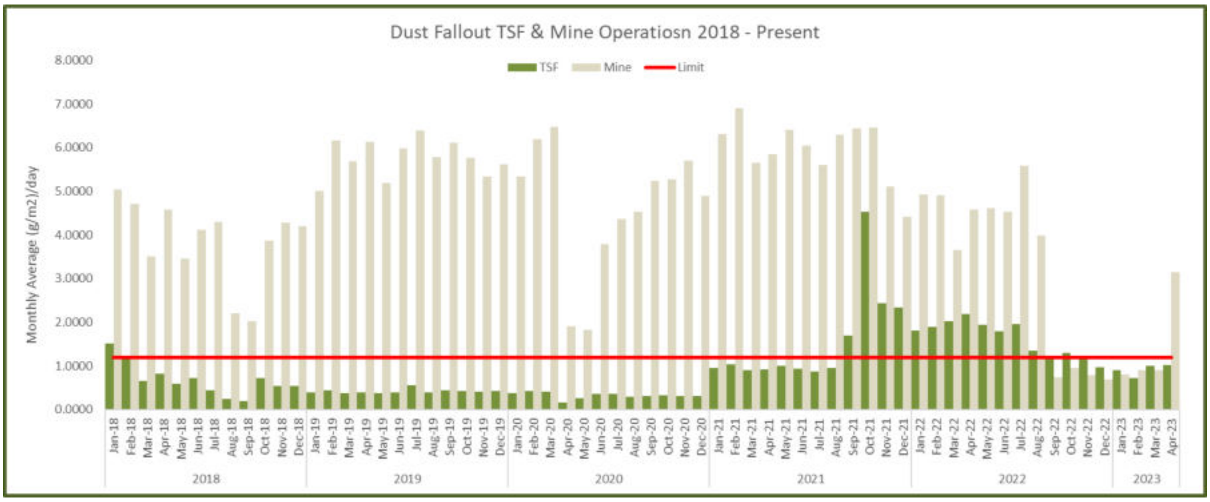


Figure 31: Industrial Dust Levels 2018 – 2020.

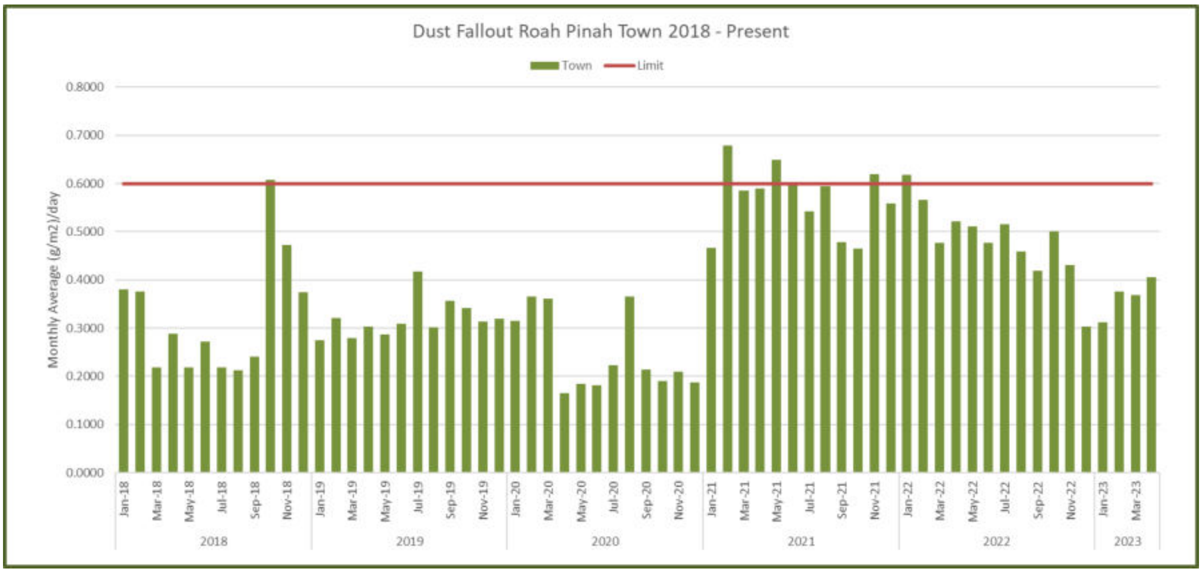


Figure 32: Residential Dust Levels March 2018 – March 2023.

Since 2014 budget was allocated to minimize the dust generated from the existing TSF. The measures introduced are:

5.2.1 Existing and future mitigation measures and expenditure to minimize dust

Crusher Circuit Projects:

- Dust Suppression around the crusher circuit and the tertiary stockpiles will be addressed by installing a dedicated system of sprinklers. The sprinkler system will be operated automatically.
- ICAT dust suppression system on the crusher conveyors will be upgraded from a water only system to a dual water and compressed air system, increasing effectiveness. Ring misters at the discharge points will also be reinstated.
- A weather station will be installed at the tertiary discharge point to trigger discharge halts in high wind events.

Dry-floor project:

- The current layout of the dry-floor will be redesigned to accommodate the Pb concentrate, eliminating the need to transport Pb concentrate on site roadways. A wheel washing station for the transport trucks is included in the redesign.

Access road project:

- The access road will be paved with interlocks to eliminate dust kicked up by the concentrate transport trucks.

Tailings Site Projects:

- A roadmap for the rehabilitation of the decommissioned tailings dam needs to be designed.
- In 2021 the old tailings dam was decommissioned. Rock cladding of this tailings dam started in 2014 and is ongoing. Dust suppression by means of spraying binding agent, mixed with water, will also be used in combination with the rock cladding activities.

Community Projects:

- An independent all emissions source modeling study will be carried out to assess and confirm the extent of the dust pollution as a contributor to the lead exposure.
- At risk Bet-El residents will be relocated to alternative parts of Rosh Pinah town.
- A soil removal strategy will be developed to clear all contaminated soil from the residential areas identified 'red zone'.

Table 12 summarises the mitigation actions and associated costs carried out for 2022.

Table 12: Mitigation actions and associated costs for 2022.

	ACTION	EXPENDITURE (N$)
Prevention	Rock Cladding	NAD 1,849,932.00
	Polymer (Bind-X)	NAD 1,050,000.00
Monitoring	PM 2.5/10	NAD 86,286.00
Health	Consultation and testing	NAD 100,100.00
	vitamins and supplements	NAD 819,000.00
Community	Rent per annum (*2022)	NAD 705,600.00
		NAD 4,610,918.00

5.3 Lead and Arsenic Concentrations in Residential Soil

Soil sampling to determine the lead and arsenic concentration in residential soil in Rosh Pinah town was conducted in 2020. During the initial sampling phase areas were identified where concentration levels were elevated. The second phase only focused on these areas to establish a perimeter. As the phase 1 results indicated no exceedance for the residential areas of arsenic, this was not analysed in the second phase.

Rosh Pinah residential areas were divided into 4 areas namely, Tutungeni (Informal Settlement), Bet-El, Main town area and areas around the TSF. During the 1st phase specific focus was given to playgrounds, schools, residential housing, day care center, hostels and considering the lead band area.

The 2nd phase focused on the high lead level areas identified during the 1st phase, which included the eastern and northern side of the main town area and the eastern and central side of the Bet-El area (**Figure 33** and **Figure 34**).

The 1st phase sampling included a total of 39 samples were collected of which 31 samples were taken at a depth of 0-15 cm and 8 samples were taken at a depth of 15 – 30 cm.

During the 2nd phase an additional 9 samples for the northern site of the Main town and 7 samples of the eastern and central side Bet-El.

Soil samples were taken at depth of 0-15 cm is commonly used to represent the direct human exposure pathway, whereas 15-30 cm is commonly used to represent the home produce exposure pathway, because the latter covers the significant root zone.

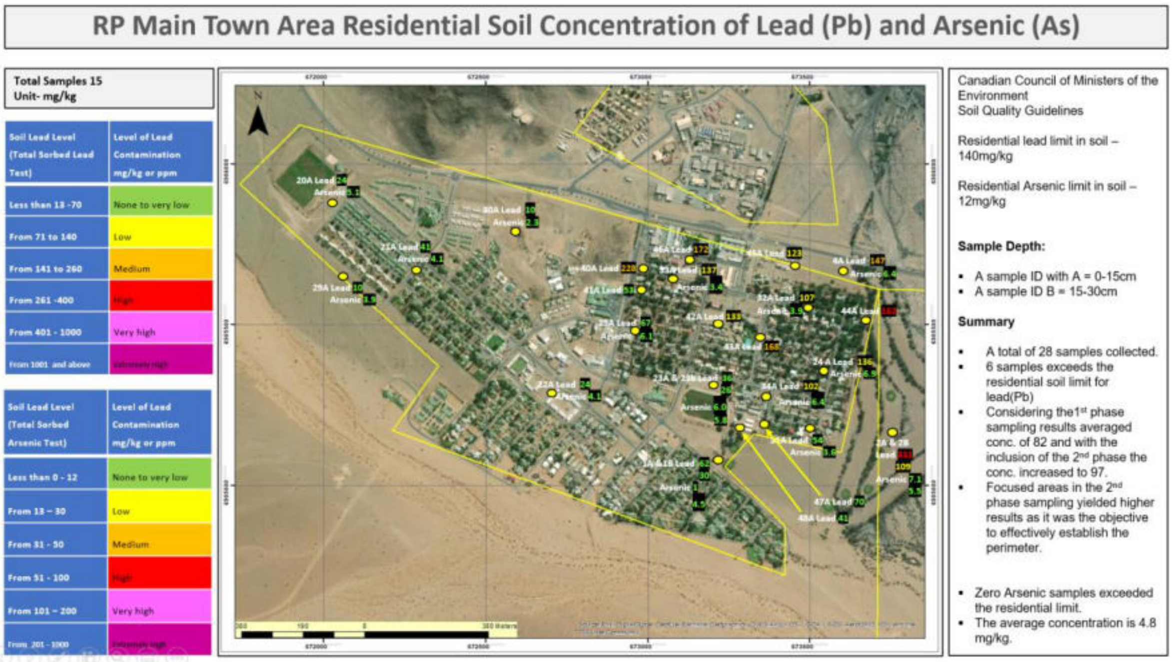


Figure 33: Main Town area residential soil concentration lead (Pb).

During the 2nd phase a total of 28 samples collected at the main Town Area of which 6 samples exceed the residential soil limit for lead (Pb) (140 mg/kg dry weight). In the 1st phase the average concentration of all samples was 82 mg/kg dry weight, while adding the results of the 2nd phase the concentration increased to 97 mg/kg dry weight. However, this was expected as the 2nd phase focused on the areas that already exceeded residential soil limit for Pb concentration in the 1st phase. The areas exceeding the residential Pb concentration have been map out and action to mitigate this will be provided in section 5.3.2.

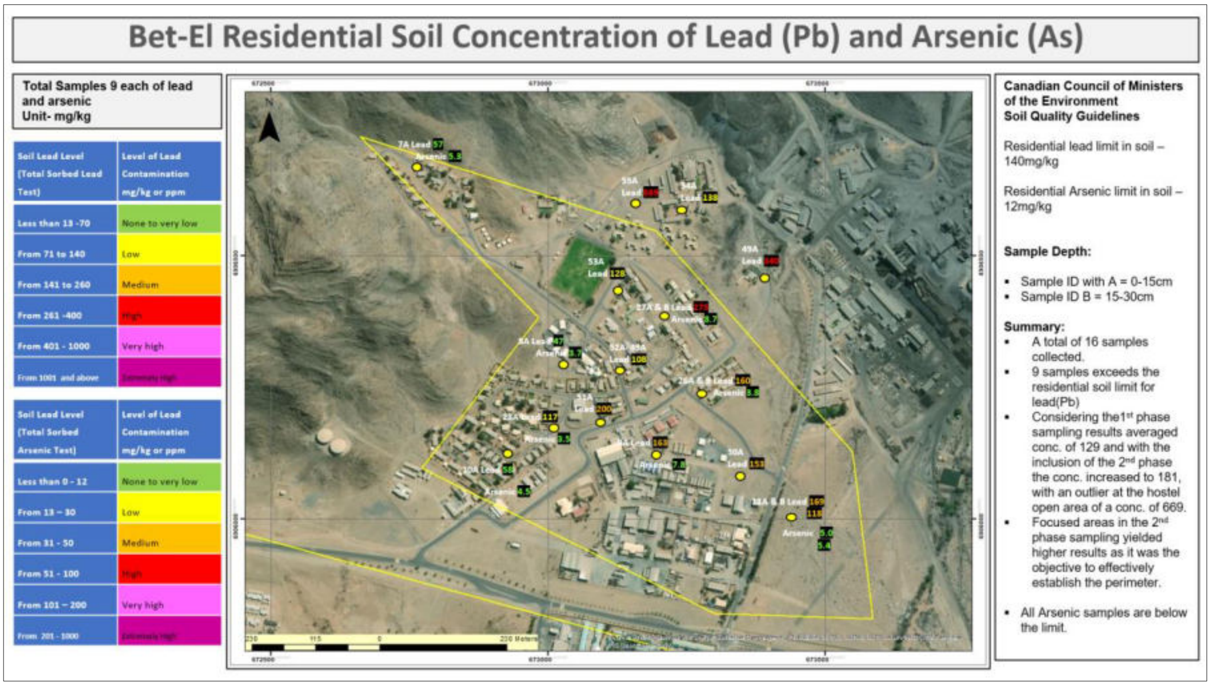


Figure 34: Bet-El area residential soil concentration lead (Pb).

During the 2nd phase a total of 16 samples were collected of which 9 samples exceeded the residential soil limit for lead (Pb) (140 mg/kg dry weight).

In the 1st phase the average concentration of all samples was of 129 mg/kg dry weight, while adding the results of the 2nd phase the concentration increased to 181 mg/kg dry weight. The hostel open area showed a concentration of 669 mg/kg dry weight.

However, this was expected as the 2nd phase focused on the areas that already exceeded residential soil limit for Pb concentration in the 1st phase. The areas exceeding the residential Pb concentration have been map out and action to mitigate this will be provided in section 5.3.2.

5.3.1 Standards and Guidelines

The Canadian Council of Ministers of the Environment soil quality guidelines were used. **Table 13** shows the lead and arsenic limits.

Table 13: Canadian Council of Ministries of the Environment (CCME) Soil Quality Guidelines.

Chemical Name	**Chemical Group**	**Concentration (mg/kg dry weight)**			
		Agricultural	Residential/parkland	Commercial	Industrial
Lead (Pb)	Inorganic metals	70	140	260	600

5.3.2 Results

The concentration of lead and arsenic from the central town towards the western side and Skorpion Zinc housing including Tutungeni is below the residential limit for soil quality. Generally averaging between 66mg/kg for lead and 4.5mg/kg for arsenic.

More than 50 years of mining operation in Rosh Pinah caused contamination of surface soils to specific area. The areas of concern are the eastern side of the management housing, golf course and the eastern side of Bet-El with elevated levels of lead concentration in soil. This is generally referred to as the lead band, where is to be assumed that lead levels would be high considering the source of contamination - the TSF for the eastern side of the management housing, golf course and the ore stockpiles for the eastern side of Bet- El - and the prevailing wind.

Major efforts have been made to reduce the dust from the TSF, with rock cladding and dust suppression which is evident in the reduction of dust levels recorded (the section 5.2).

At Bet-El residential properties where lead levels were elevated have been paved to ensure that lead dust blown from the ore stockpile can be easily cleaned by sweeping.

Further dust reduction initiatives will be stated in the EMP section.

The importance of good hygiene practices cannot be over emphasized. This is part of Occupational Hygiene programme at the mine and now includes as well residents focusing especially on schools.

5.4 Blood lead level measurements of employees

Since 1992 blood lead levels (BLL) are measured of all employees. All employees are below the Namibian limits of 70 µg/dL for males and 40 µg/dL for females (as set out in Labour Act of 1992), while some employees at the engineering and plant department are above the limit Rosh Pinah mine set themselves (20 µg/dL). The results from the last 3 years are shown in **Figure 35**.

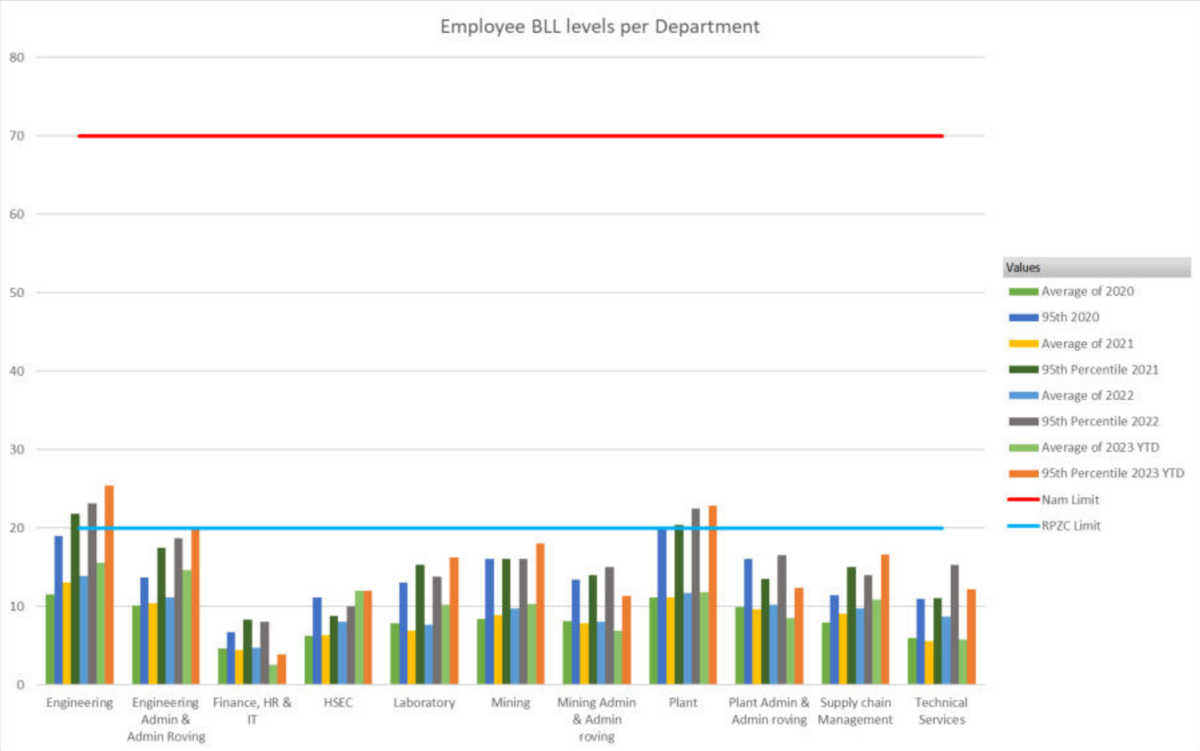


Figure 35: Blood lead level (BLL) of employees per department.

5.5 Overall Environmental Management Procedures

Below the overall environmental management procedures implemented at Rosh Pinah Mine are listed:

- Bio-Remediation Manual
- Surface Disturbance Procedure
- Waste Management Procedure
- Water Quality Monitoring Procedure
- Dust Management Procedure
- Management of Hydrocarbon Spillages Procedure
- Fauna and Flora Management Procedure

6 POTENTIAL IMPACTS ARISING FROM THE RP2.0 EXPANSION PROJECT AND THEIR MITIGATION MEASURES

Potential Impact arising from the different operational areas of PR2.0 Expansion Project are listed below, as well as their mitigation measures, which are in place. Please note that all of the potential impacts listed below have already been addressed in the original EIA/EMP (ASEC, 2008) and been addressed in the environmental management system at Rosh Pinah Mine.

Operational Area	Potential Impacts	Mitigation/management measures
Underground mining	• Visual impact of waste rock dumps • Dust from tipping of waste rock • Primary crusher dust in underground mine area and surface through ventilation shafts • Breaching of water bearing fissure • Diesel fumes underground • Dust inhalation by underground workers (lead, zinc, sulphides etc.) • Noise protection of workers underground • Nitrate (NO_3^-) contamination inside the mining areas where nitrate-based explosives are used (explosive: Anfex)	All these impacts are addressed in the ISO 14001 management procedures
PR2.0 Expansion Project infrastructure	• Dust from ore stockpiles although a reduction is envisioned with the new SAG mill and additional upgrades to the process operation • Potential to pollute the soils and groundwater from spillages during the flotation process • Spillage of tailings slurry from the tailings dam pipeline • Storage and handling of chemicals used in process • Potential negative health effects from dust of all forms, but particularly the lead/zinc concentrate and ore	All potential impacts are addressed in the ISO 14001 management system. Regarding dust from tailings dam, Fraser Alexander presented potential mitigation measures on in the form dust suppression sprinklers, Road Dust and Rock cladding applications of which the latter two have been successfully executed. This is apparent it the reduction of dust level at Rosh Pinah Village and TSF locations, please refer to Section 5.2 (Industrial and Residential Dust level).

Operational Area	Potential Impacts	Mitigation/management measures
Bulk Storage and Handling diesel	▪ Fire hazard	All fuel used at RPZC mine is stored and handled according to international standards. ISO 14001 management procedures and emergency procedures are in place.

6.1 Potential impacts from lead dust to residents of Rosh Pinah and mitigation measures

In 1968 the town of Rosh Pinah came into being when the first major mining operation, Rosh Pinah Zinc Corporation (RPZC) was set up in the area. When Skorpion Zinc mine and zinc extraction/ production plant opened in 2003, Rosh Pinah's population continued to increase rapidly.

Rosh Pinah is not a proclaimed town and does not have a municipality. The town is under the control of the two mines, RPZC and Skorpion Zinc, who manage the town via RoshSkor Township (Pty) Ltd. There are a lot of stakeholders involved in the process to transfer the town to Government, which is the main driver of the process. As of last year, it was agreed to embark on a sustainability plan for the town[8].

The land on which Rosh Pinah is situated falls within the two mines' accessory works area – land made available by Government for a mine to develop accommodation and other facilities to improve the quality of life of their employees.

Would the mine and accommodation for workers been developed now adays the impact on dust on residents would been taken in consideration to where to site the residential area. Rosh Pinah has now to mitigate the historical wrong doing to protect the health of their residents.

This Appendix provides a brief summary of the pathways of lead dust and the resulting health risks. The information was mainly taken from the 'Lead Pathways Study – Air, Executive Summary of the Health Risk Assessment of Contaminants to Mount Isa City compiled by authors of the Universities of The University of Queensland and University of Adelaide.

6.1.1 Potential Pathways of lead dust

The information below is a summary of the pathways of lead dust and the resulting health risks. The information was mainly taken from the 'Lead Pathways Study – Air, Executive Summary of the Health Risk Assessment of Contaminants to Mount Isa City compiled by authors of the Universities of The University of Queensland and University of Adelaide.

Potential exposure pathways of lead into the human body are:

- ingestion through the mouth and, subsequently, the digestive system,
- inhalation through the mouth and nose into the lungs,
- absorption through the skin.

[8] Pers. comm. Ronnie Slabbert, Town Manager, RoshSkor, September 2019

The two major routes of lead absorption by the human body are through ingestion and inhalation pathways, whereas absorption through the skin is considered to be insignificant (IPCS, 1995).

Ingestion through the mouth into the digestive system can be through food and drink, or through non-nutritive substances such as dirt and paint. Babies and small children often put their thumbs or fingers in their mouths, which can result in transferring lead-contaminated dust into their mouths.

Particles less than 250 µm in size are the most likely to enter through the ingestion route because coarser particles are less likely to adhere to hands and be transferred to the mouth.

Age is a significant variable for lead absorption and metabolism. The portion of ingested lead taken up by the body is typically less than 5 per cent for adults, but as high as 50 per cent for children (Zeigler et al., 1978). Infants and toddlers are at greater risk due to increased exposure (through hand-to-mouth behaviour), increased ability to absorb lead, the susceptibility of their rapidly developing central nervous systems, and their less-developed gastrointestinal tract (Maynard et al., 2005).

The inhalation pathway consists of breathing in solid particles or liquid droplets found in air. Particles and droplets that are less than 10 micrometres ('µm') in diameter (known as 'PM_{10}' particles) and those less than 2.5 µm ('$PM_{2.5}$' particles) pose the greatest problems for human health, because they can penetrate deep into the lungs and get into the bloodstream (IPCS, 1995). Particles larger than about 7 µm tend to depositon the walls of the airways (the thoracic region) and become part of the mucus that is moved up to the mouth and then swallowed (IPCS, 1995). $PM_{2.5}$ gives an approximation for fine mode particles, and therefore alveolar deposition, while PM_{10} indicates the thoracic aerosol component (Raunemaa, 2002).

Lead absorbed through ingestion or inhalation moves into the body's circulatory system and from there can move into various organs or the bones. Lead is gradually excreted from the body. Two important routes of lead excretion from the body are urine and faeces (IPCS, 1995).

A lead uptake study indicated that 20 per cent of dosed lead was bound to the skeleton after three weeks (Heard and Chamberlain, 1984). The half-life of lead in the human body is approximately 30 days in blood stream and 10–30 years in bone (JECFA, 2011).

6.1.2 Health Effects

Lead exposure can have serious consequences for the health of children. At high levels of exposure to lead the brain and central nervous system can be severely damaged causing coma, convulsions and even death. Children who survive severe lead poisoning may be left with permanent intellectual disability and behavioural disorders. At lower levels of exposure that cause no obvious symptoms, lead is now known to produce a spectrum of injury across multiple body systems. In particular, lead can affect children's brain development, resulting in reduced intelligence quotient (IQ), behavioural changes such as reduced attention span and increased antisocial behaviour, and reduced educational attainment. Lead exposure also causes anaemia, hypertension, renal impairment, immunotoxicity and toxicity to the reproductive organs. The neurological and behavioural effects of lead are believed to be irreversible.

There is no known safe blood lead concentration; even blood lead concentrations as low as 3.5 µg/dL may be associated with decreased intelligence in children, behavioural difficulties and learning problems (US CDC Advisory Committee on Childhood Lead Poisoning

Prevention. CDC updates blood lead reference value to 3.5µg/dL. Atlanta: US Centres for Disease Control and Prevention; 2021).

Area	Potential Impacts	Mitigation/management measures
Lead dust from the TSF and ore stockpile in residential areas (eastern and northern side of the main town area and the eastern and central side of the Bet-El)	• Health risks through lead dust inhalation, indigestion and absorption through skin	• ***Mine operations:*** Continue to focus on effective measures to reduce mine dust transfers from key lead sources at the mine site operations, such as ore stockpile and TSF. • ***Maintaining the residential (home) environment:*** Bare patches in gardens should be covered with grasses or bricks. Carpets should be replaced with timber or other hard floor coverings, and cleaned with phosphate-based cleaning agents. Phosphate is known to immobilise lead and reduce it's bioavailability upon ingestion. Houses should be cleaned frequently, by vacuuming and wiping away any accumulated dust (preferably with a damp cloth). Pet ownership should be reviewed in areas with elevated lead concentrations in the soils. • ***Personal hygiene:*** Ensure children clean their hands frequently, particularly before meals. Try to reduce children's

Area	Potential Impacts	Mitigation/management measures
		habits such as sucking non-food items. Keep children away from all potential sources of lead from both geogenic and anthropogenic origins. • ***Attention to diet:*** Wash home grown fruit and vegetables thoroughly before eating/cooking; peeling root crops will also reduce lead exposure. Better still: avoid eating home grown vegetables and fruits whose skin cannot be peeled before consuming. Good nutritional food contains certain food components that can also reduce lead adsorption resulting in lower blood lead.

7 CONCLUSION AND COMMITMENTS

The reason why no environmental assessment has been carried out, is due to the following reasons:

- RP2.0 Expansion Project is situated within the existing Mining Licence area, which is not a green field site.
- No virgin land will be impacted by the RP2.0 Expansion Project.
- Environmental management systems are in place at the mine and well implemented.
- Dust monitoring showed that no exceedance occurred since October 2018. With the new crushing arrangements on surface and due to the larger feed ore size (120 to 250mm, with a 90% pass rate at 150mm) that the SAG mill will be able to receive. With the new arrangement, the current tertiary and secondary crushers on surface will become redundant as the feed into the SAG mill will be directly form the primary crusher, hence less fine material stored on surface.
- RPZC has an Occupational Health, Safety and Environment Commitment (HSEC) Policy (2017) outlining RPZC's commitment to continual improvement, management of biodiversity and ecosystems and the undertaking of business in an environmentally sound manner. These commitments are implemented and managed through a certified ISO 14001:2015 Environmental Management System (EMS); the current certification is valid until August 01, 2023. A certified ISO 14001: 2015 Management System is a

requirement for IFC Performance Standards (in particular, Performance Standard 1- Assessment and Management of Environmental and Social Risk and Impacts) and good international industry practice.

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