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A&B GLOBAL MINING

Exhibit 96.5

Hindustan Zinc Limited – SEC - SK 1300

Technical Summary Report

Zawar Group of Mine

Document Version:	**Rev 1**
Customer Name:	**HZL Mine**
Date:	**20 July 2022**
Prepared by:	**ABGM**
Document Number:	**2022-07-25-ZAW-SEC**

PREPARED AND REVIEWED BY:

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TITLE	NAME	SIGNATURE	DATE
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Qualified Person - Reserves	Bill Gillespie		28/07/2022
Managing Director - ABGM	Devendra Vyas		28/07/2022

Disclaimer:

This document will serve only for the Purposes of Hindustan Zinc Limited (HZL) based on information received from the mine and its respective mining operations in India namely: Rampura Agucha Mine; Rajpura Dariba; Sindesar Khurd; Kayad and the four Zawar operations – Balaria, Baroi, Mochia and Zawarmala, the data requested was complete / incomplete with assumption made for delivery. The information within this technical report is aligned to the Securities Exchange Commission (SEC), SK-1300 guidelines and the information within is to be use for this purpose only.

LIST OF ABBREVIATIONS:

%	Percentage
^{0}C	degree Celsius
ABGM	A & B Global Mining Consultants
Ag	Silver
BOQ	Bill of Quantities
CAPEX	Capital expenditure
Coeff. Of Variation	coefficient of variation
COG	Cut-off Grade
Con	Concentrate
CSD	calc-silicate dolomites
g/t	grams per ton
GMS	graphite-mica schist
GSSA	Geological Society of South Africa
HDPE	High Density Polyethylene
Hr.	Hour
HZL	Hindustan Zinc Limited
IDW^2	Inverse Distance Weighting to the power of two
INR	Indian Rupee
kA	KiloAmpere
kL	KiloLitre
km	Kilometre
kN/m^2	KiloNewton per square metre
Koz	Kilo Ounces
Kt	Kilo tonne
kV	KiloVolt
lb	Pound
LHD	Load Haul Dumper
LOM	Life-of-Mine
LOM	Life of Mine
m	metre

m^2	Squared Metre
m^3	Cubic Metre
m^3/hr	Cubic metres per hour
mRL	Mean Relative Elevation
Mt	Million tonnes
mtpa	Million tonnes per annum
OGL	Original ground level (original surface elevation)
OK	Ordinary Kriging
OPEX	Operating expenditure
oz	Ounces
Pb	Lead
PbEQ	Lead Equivalent
PFS	Preliminary Feasibility Study
QA	Quality Assurance
QC	Quality Control
RAM	Rampura Agucha Mine
RAUG	Rampura-Agucha underground
RDM	Rajpura Dariba Mines
ROM	Run-of-Mine (ore/rock of economic value containing the target mineral(s)
ROM	Run of Mine
RPEEE	reasonable prospects of eventual economic extraction
SACNASP	South African Council for Natural Scientific professions
SEC	Securities Exchange Commission
SKM	Sindesar Khurd
Std Dev	standard deviation
t	tonnes
TRS	Technical Review
USD	Us Dollar
USD/g	US Dollar per gram
USD/pb	US Dollar per pound
USD/t	US Dollar per tonne

VDS/PDS	Vehicle Detection System / Personnel Detection System
ZAW	Zawar Complex
Zn	Zinc
ZnEQ	Zinc Equivalent

Glossary of Terms

Block model: This is the cubical representation in three dimensions of the Mineral Resource. The block model data is usually constructed using industry accepted geological software packages.

Concentrating: The process of separating milled ore into a waste stream (tailings) and a valuable mineral stream (concentrate) by floatation.

Orebody: A well-defined mineralised rock mass that can be defined or modelled based upon its distinct mineral content or associated rock type/lithology.

Run of Mine (ROM): A loose term used to describe ore produced from the mine available for processing.

Tailings: That portion of the ore from which most of the valuable material has been removed by concentrating and that is therefore low in value and rejected.

Tonne: Metric tonne, equal to 1000 kg, unless otherwise defined.

Total Station: Surveying tool which comprises an electronic theodolite and an electronic distance meter/measurement component.

Note that all physical measurements units used in this report are metric, i.e. based on the International System of Units (SI units), unless otherwise indicated.

Finance

Capital expenditure (CAPEX): Total capital expenditure on mining and non-mining property, plant, equipment, and capital work-in-progress.

Effective tax rate: Current taxation, deferred taxation, and tax normalization as a percentage of profit before taxation.

IRR: Internal Rate of Return (the discount rate at which the project "NPV" becomes zero).

NPV: Net Present Value (cash flow of the project discounted to current day value – includes project OPEX and CAPEX).

Operating expenditure (OPEX): Total operating expenditure for mining and non-mining functions pertaining to the project.

Definitions:

The following definitions apply to this report and are aligned to meanings ascribed in terms of internationally recognized institutions and standards namely the Canadian CIM Definition Standards for Mineral Resources and Mineral Reserves 2014 (CIM), The Australian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves 2012 Edition (JORC) and The South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves 2016 (SAMREC).

Mineral Resources:

A **'Mineral Resource'** is a concentration or occurrence of material of intrinsic economic interest in or on the earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. Mineral Resources are further sub-divided, in order of increasing geological confidence, into Inferred, Indicated and Measured as categories.

Inferred Mineral Resource is the part of a Mineral Resource for which quantity, grade (or quality) and mineral content can be estimated with a low level of confidence. It is inferred from geological evidence and assumed but not verified geological or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes which may be of limited or uncertain quality and reliability.

Indicated Mineral Resources are economic mineral occurrences that have been sampled (from locations such as outcrops, trenches, pits and drill holes) to a point where an estimate has been made, at a reasonable level of confidence, of their contained metal, grade, tonnage, shape, densities, physical characteristics.

Measured Mineral Resources are Indicated Mineral Resources that have undergone enough further sampling that a 'competent person' or ‘qualified person’ (defined by the norms of the relevant mining code; usually a geologist) has declared them to be an acceptable estimate, at a high degree of confidence, of the grade (or quality), quantity, shape, densities, physical characteristics of the mineral occurrence.

Ore Reserves / Mineral Reserves

An Ore Reserve or Mineral Reserve is the economically mineable part of a Measured Mineral Resource and/or Indicated Mineral Resource. Mineral Reserves are subdivided in order of increasing confidence into **Probable Mineral Reserves** or **Proved Mineral Reserves**.

Probable Mineral Reserve is the economically mineable part of an Indicated Mineral Resource, and in some circumstances, a Measured Mineral Resources. It includes diluting material and allowances for losses which may occur when the material is mined. A Probable Mineral Reserve has a lower level of confidence than a Proved Mineral Reserve but is of sufficient quality to serve as the basis for decision on the development of deposit.

Proved Mineral Reserve is the economically mineable part of a **Measured Mineral Resource**. It includes diluting materials and allowances for losses which occur when the material is mined.

Proved Mineral Reserve represents the highest confidence category of Mineral Reserve estimate. It implies a high degree of confidence in the geological factors and a high degree of confidence in the Modifying Factors. The style of mineralization or other factors could mean that Proved Mineral Reserves are not achievable in some deposits.

Generally the **conversion** of Mineral Resources into Mineral Reserves requires the application of various **Modifying Factors**, including, but not restricted to:

- mining factors
- mineral processing / ore dressing related factors

- metallurgical factors
- infrastructure factors
- economic factors
- marketing factors
- legal factors
- ESG factors: Environmental, Social (including Health and Safety) and Governance.

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1 EXECUTIVE SUMMARY

1.1 Property summary and ownership

The Zawar Mines are situated approximately 44 km from Udaipur. HZL's total leasehold area is 36.20 km^2, of this 31.72 km^2 mining lease, covering the four mines in active production (Block-1) and, about 10 km further south, the Block-3 area (4.48 km^2) covering current exploration activities. Block-1 comprises four mines: Mochia, Balaria, Zawarmala, and Baroi and the integrated concentrators. Block-3 does not form part of the current mine plan.

The exploration by HZL started in 2005 with 196 boreholes underground for a total of 6,018 m and by 2021, they had completed 10,438 boreholes for a total of 744,973 m. The exploration drilling from surface started in 2007 with one borehole to a depth of 1,510 m and by 2021, they had completed 572 boreholes for a total of 426,005 m.

In February 2015, The Department of Mines & Geology of the Government of Rajasthan extended the lease validity until March 2030 as per Section 8A (5) of MMRD (Amendment) Ordinance 2015.

1.2 Mineral Resource Statement

The Mineral Resources exclusive of the Mineral Reserves as at the end of the last fiscal year are summarised below and the same period where the Mineral Resources are inclusive of the Mineral Reserves.

The Mineral Resources are reported at a ZnEQ COG of:

- Balaria 3.36%
- Baroi 2.56%
- Mochia 2.67%
- Zawarmala 3.44%.

Table 1: Zawar Mineral Resource Statement (exclusive of Mineral Reserves) – 31 March 2022

Classification	Tonnage	Grade			Metal Content		
	(Mt)	Zn (%)	Pb (%)	Ag (g/t)	Zn (Kt)	Pb (Kt)	Ag (Koz)
Measured	26.4	3.40	2.00	29	909	517	24,549
Indicated	10.3	3.20	2.00	27	327	209	8,984
Measured + Indicated	**36.8**	**3.40**	**2.00**	**28**	**1,236**	**726**	**33,532**
Inferred	79.3	3.60	2.10	34	2,852	1,695	87,051
Total	**116.1**	**3.50**	**2.10**	**32**	**4,088**	**2,421**	**105,583**

The Measured Mineral Resources as a proportion of the total Inclusive Mineral Resource as of 31 March 2022 accounts for ~30% of the tonnes, the Indicated Mineral Resources is ~15%, and the Inferred at ~55% .

Table 2: Mineral Resource Statement (inclusive of Mineral Reserves) – 31 March 2022

Classification	Tonnage	Grade			Metal Content		
	(Mt)	Zn (%)	Pb (%)	Ag (g/t)	Zn (Kt)	Pb (Kt)	Ag (Koz)
Measured	44.6	3.90	1.90	31	1,722	853	45,101
Indicated	21.1	3.80	1.90	32	793	398	21,749
Measured + Indicated	**65.7**	**3.80**	**1.90**	**32**	**2,515**	**1,251**	**66,850**
Inferred	79.3	3.60	2.10	34	2,852	1,695	87,051
Total	**145**	**3.70**	**2.00**	**33**	**5,368**	**2,946**	**153,901**

1.3 Mineral Reserve Statement

The HZL mine operations and technical teams engage on annual industry statutory evaluation and conduct standard works that is applied across all the mine operation from the geology resource estimations to applying the mine designs and evaluating the potential Mineral Reserves. The HZL Resources and Reserves technical team has kept extensive data that is used annually to do the statutory mineral reserves statements and calculations that is audited and supervised by reputable consultant houses. Each mine undergoes individual assessments and apply the modifying factors, grade cut-off calculation and assumptions.

ABGM collated the data and reviewed the mine designs, input parameters and mine design criteria for the mine operation.

The Mineral Reserve statement (March 2022) suggests ZAW has 37.9Mt at 2.8g/t Zinc, 1.2% Lead and 23 g/t Silver within the minable Ore Reserve.

Table 3: Mineral Reserves Estimates (2022)

Ore Reserve summary							
Ore Reserve	Tonnage (Mt)	Grade (Zn %)	(Pb %)	(Ag g/t)	Metal (Zn kt)	(Pb kt)	(Ag koz)
Zawar Mines							
Proved	23.5	2.8	1.2	23.0	661	286	17,063
Probable	14.4	2.8	1.2	24.0	401	167	11,097
Ore Reserves (Total)	**37.9**	**2.8**	**1.2**	**23.0**	**1,062**	**452**	**28,160**

1.4 Geology and Mineralization

The Zawar lease area is situated in NW-SE trending hills of Rajasthan and is of Paleo-Proterozoic age (1700-1800 Million Years). All the deposits at Zawar are hosted by epizonal metamorphosed dolomites of the Tiri Formation, Aravalli Supergroup (1.7 – 1.8 Ma), either in north-south structures (Post-Aravalli orogeny) or in W-E structures (Delhi orogeny). The mineralisation comprises sphalerite and galena as disseminations or veinlets in bodies defined by grade contacts only. Silver mineralisation has been concentrated in the upper levels of the mines which have been depleted either by historical mining or earlier modern mining.

The deposits are either tabular, steeply northeast-dipping and west-plunging (Mochia and Balaria), or complex-shaped lenses following the Northern plunge of a fold-axis (Zawarmala). At Baroi, mineralisation is largely disseminated and organised in poorly constrained Northwest dipping bodies.

The main ore minerals at Zawar are, in order of abundance: sphalerite, pyrite and galena, although at Baroi, galena is the predominant base metal sulphide mineral. All Zawar ore is indicated to be "clean" and easy to liberate with minimal level of metal impurities or other contaminants reporting into the concentrates. The base metal sulphides are indicated to be mainly associated with the gangue minerals and can be liberated at relatively coarse size with little intergrowth of the lead and zinc minerals. Cadmium is reported to occur with sphalerite while silver occurs predominantly in solid solution with galena.

1.5 Metallurgical Testing

The HZL has a network of operations across India and ZAW is currently an operating mine with a working CPP with many years of operations behind them. The mineral processing is well understood and there is no need to conduct any additional metallurgical test work at the current operations.

1.6 Mine Design, Optimizations and Scheduling

The current mine designs implemented at Zawar Complex namely Zawarmala, Mochia, Baroi, and Balaria is to date been successfully extracted and maintained as per the original design. There is currently no indication that the mine cannot continue in the current stage. The designs has made sufficient provisions for a crown pillar that will be mined out at the end of mine life.

The mines are scheduled to produce 5mtpa collectively in 2022 and ramp up to 6.5mtpa until Baroi and Zawarmala are depleted, when it will gradually decrease to 2mtpa from 2027 onwards. Currently no optimisation in the scheduling has been observed and this will be addressed in the near future.

Table 4: LOM Schedule - Zawar Mines - 2022 – 2031 [supplied by HZL]

Reserves	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Mochia	1,600,000	1,800,000	2,200,000	2,200,000	2,200,000	369,000			
Balaria	1,050,000	1,500,000	1,918,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Baroi	1,750,000	2,000,000	2,000,000	1,974,000					
Zawarmala	600,000	750,000	750,000	750,000	488,000				
ZAWAR-Total	**5,000,000**	**6,050,000**	**6,868,000**	**6,924,000**	**4,688,000**	**2,369,000**	**2,000,000**	**2,000,000**	**2,000,000**
Sus Dev Requirement (m)									
Mochia	6,700	7,500	9,200	9,200	9,200	1,500	-	-	-
Balaria	5,300	7,500	9,600	10,000	10,000	10,000	10,000	10,000	10,000
Baroi	9,900	11,300	11,300	11,200	-	-	-	-	-
Zawarmala	1,800	2,300	2,300	2,300	1,500	-	-	-	-
ZAWAR-Total	**23,700**	**28,600**	**32,400**	**32,700**	**20,700**	**11,500**	**10,000**	**10,000**	**10,000**
Sus Dev Requirement (cum)									
Mochia	147,400	165,000	202,400	202,400	202,400	33,000	-	-	-
Balaria	116,600	165,000	211,200	220,000	220,000	220,000	220,000	220,000	220,000
Baroi	198,000	226,000	226,000	224,000	-	-	-	-	-
Zawarmala	36,000	46,000	46,000	46,000	30,000	-	-	-	-
ZAWAR-Total	**498,000**	**602,000**	**685,600**	**692,400**	**452,400**	**253,000**	**220,000**	**220,000**	**220,000**

1.7 Mineral Processing

The ROM ore from the four mines comprising the Zawar mining complex is treated at a central mineral processing plant located in the main administrative area close to the Mochia and Balaria mines.

The mineral processing consists of:

- transportation of ROM ore to the processing facility,
- communition (crusher and grinding),

- concentration (floatation),
- drying of concentrate (thickening and filtration).
- dispatch of concentrate to smelter(s), and
- transportation of rejects (tailings) to a tailings storage facility.

Separate Pb+Ag and Zn concentrates are produced. Smelting and refining are done at captive metallurgical complexes of HZL. The processing plant consist of two independent assemblies:

- "Mill 1" has capacity to treat 2.7 Mtpa - this plant is the older of the two.
- "Mill 2" has capacity to treat 2.0 Mtpa. Mill 2 was commissioned in March 2019.

Plans are being developed to increase the capacity of Mill 2 to 2.5 Mtpa through a de-bottlenecking exercise. The main ore minerals at Zawar are, in order of abundance: sphalerite, pyrite and galena, although at Baroi galena is the predominant base metal sulphide mineral.

Table 5: Typical physical characteristics of ROM ore feed at Zawar

ROM Ore Characteristics	Value
Average moisture content	2% (Maximum 5%)
Angle of Repose	35 degrees
Bulk Density for designing purpose	1.8 MT/M3
Bond Work Index	9.5 KWH/ST
Specific Gravity of Ore	2.85
Compensated Work Index	11.8
Chemical Composition of Feed Ore	**Value**
% Lead in feed	1.95% +/- 0.5%
% Zinc in feed	3.18% +/- 0.5%
Ag in feed	30 – 40 ppm
% Fe in feed	5% - 6%

1.8 Environmental, Permitting and Community Impact

The Zawar Complex is doing sufficient work around the environmental assessments and are continuously monitoring all vital statutory aspects required. There is various sites and locations where site monitoring is conducted in regard to the following main elements:

- Land Use
- Water Quality and Management
- Air Quality

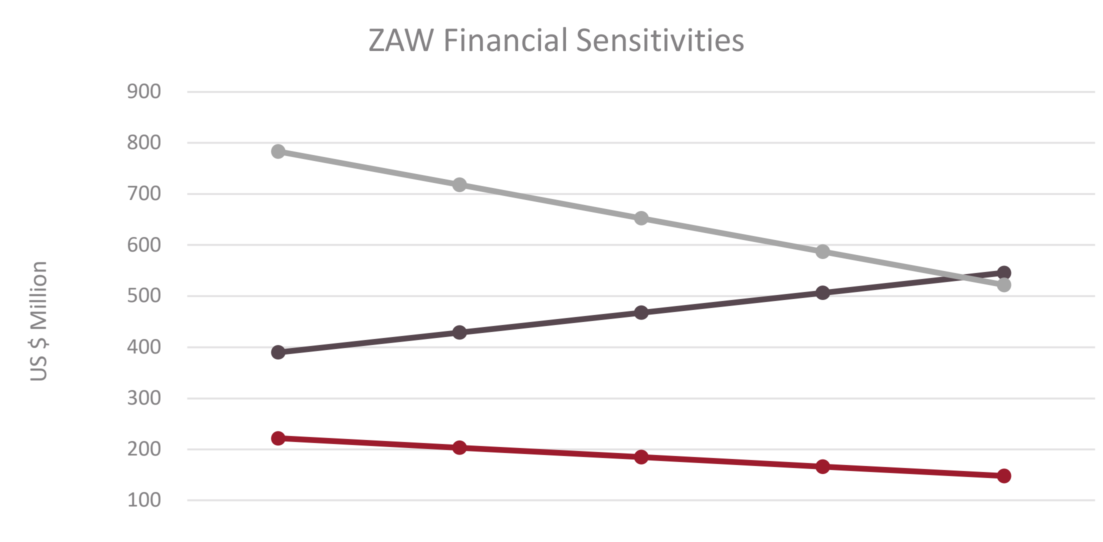
- Noise Pollution
- Soil Monitoring
- Tailing disposal

The mine is also engaging with the local communities to ensure alignment with EIA requirements overall. The mine is also planning, reviewing and executing the annual mine closure plan as required by IBM.

1.9 Capital Costs, Operating Costs and Financial Analysis

As this is an operating mine, HZL provided their operational estimates for the mine operations to develop financial sensitivities.

The operating costs for ZAW is indicated in this document and financial sensitives indicate that ZAW is not very sensitive to economic parameters at plus and minus 20%.



	20%	10%	100%	-10%	-20%
Cashflow	222	203	185	166	148
Cost	390	429	468	507	546
Revenue	783	718	653	587	522

Figure 1: ZAW Financial Sensitivity Analysis (unit: Million US $)

2 Introduction

2.1 Terms of Reference and Purpose of the Report

A&B Global Mining (ABGM) was commissioned by Hindustan Zinc Limited (HZL) to prepare a review on the Mineral Resources and Ore Reserves – 31 March 2022 Statement, for the following mine operations that are operated by HZL namely:

- Rampura Agucha (RAM)
- Kayad (KDM)
- Sindesar Khurd (SKM)
- Rajpura Dariba (RDM)
- Zawar Mines (ZAW)

This report is a Technical Report Summary (TRS) which summarizes the findings of the review in accordance with Securities Exchange Commission Part 229 Standard Instructions for Filing Forms Regulation S-K subpart 1300 (S-K 1300).

The purpose of this TRS is to report the review of Resource and Reserve Estimates as stated in their Draft document dated 31 March 2022, and to review the data & information received from HZL that will potentially be included in the 2022 Resource and reserve Statement Technical report. The effective date of this report is 29 July 2022.

The quality of information, conclusions, and estimates contained herein is based on the data and information received from HZL and is consistent with the level of effort involved in ABGM's services, based on:

i. information available at the time of preparation,
ii. data supplied by the client, and
iii. the assumptions, conditions, and qualifications set forth in this report.
iv. The time available to complete this review

Any opinions, analysis, evaluations, or recommendations issued by ABGM under this report are for the sole use and benefit of HZL. Because there are no intended third-party beneficiaries, ABGM (and its affiliates) shall have no liability whatsoever to any third parties for any defect, deficiency, error, omission in any statement contained in or in any way related to its deliverables provided under this Report.

2.2 Sources of Information

HZL provided AGBM with access to a data room housed in EthosData. Here HZL delivered the required documentation and design data from the modelling to the string. Point and wireframes used in the development of the resources model estimates and the reserve estimates.

Figure 2: File Structure and extraction source of data

2.3 Qualified Persons and Details of Inspection

A comprehensive site visit was conducted in the week of 17 July to 25 July 2022. The objectives of the site visits was to conduct the following:

- Physical verification of the mining operations and onsite infrastructure.
- Obtain outstanding information required to complete the technical report.
- Interact with the mine technical team to obtain further clarifications.

Three consultants from ABGM attended the site visits at the various mines.

- **Devendra Vyas:** Managing Director and Principal Mining Engineer
- **Andre van der Merwe:** General Manager and Principal Consultant (Geophysics, Hydrogeology, Geology, Mineral Processing and Environmental Engineering)
- **Pieter Groenewald:** Head – Technical Services and Principal Consultant (Rock Engineering and Hydrogeology)

2.4 Previous Reports on the Project

This is the only SEC -S-K 1300 TRS, A&B Global Mining (ABGM) has submitted for the Hindustan Zinc Limited (HZL) and authors are not aware of any other TRS submitted by prior owners of the project.

3 Property Description and Locations

3.1 Property Location

Zawar lease area is situated in NW-SE trending hills of Rajasthan and is a type of area of Paleo-Proterozoic age (1700-1800 Million Years). The lithological sequence comprises of meta-sedimentary rocks overlying a basement (Sarara inlier) contemporary to BGC (Banded Gneissic Complex) of Rajasthan.

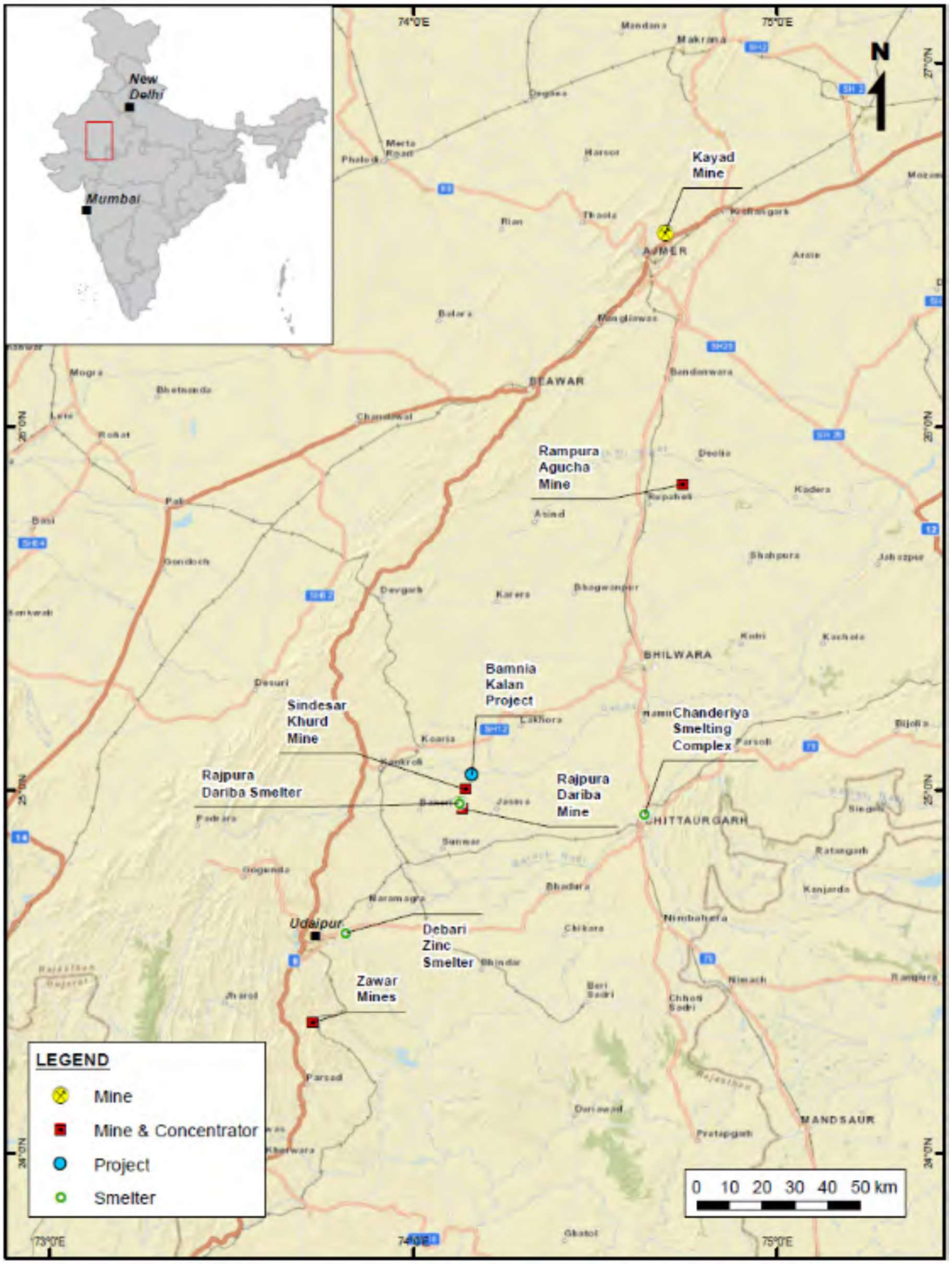


Figure 3: HZL Mine Locations

The Zawar lease area is situated in NW-SE trending hills of Rajasthan and is an area of Paleo-Proterozoic age (1700-1800 Million Years). The lithological sequence comprises of meta-sedimentary rocks overlying a basement (Sarara inlier) contemporary to BGC (Banded Gneissic Complex) of Rajasthan.

The Zawar Mines are situated approximately 44 km from Udaipur. HZL's total leasehold area is 36.20 km^2, of this 31.72 km^2 mining lease, covering the four mines in active production (Block-1) and, about 10 km further south, the Block-3 area (4.48 km^2) covering current exploration activities. Block-1 comprises four mines: Mochia, Balaria, Zawarmala, and Baroi and the integrated concentrators. Block-3 does not form part of the current study. The mining licence has been extended by the Government of Rajasthan to 31st March 2030.

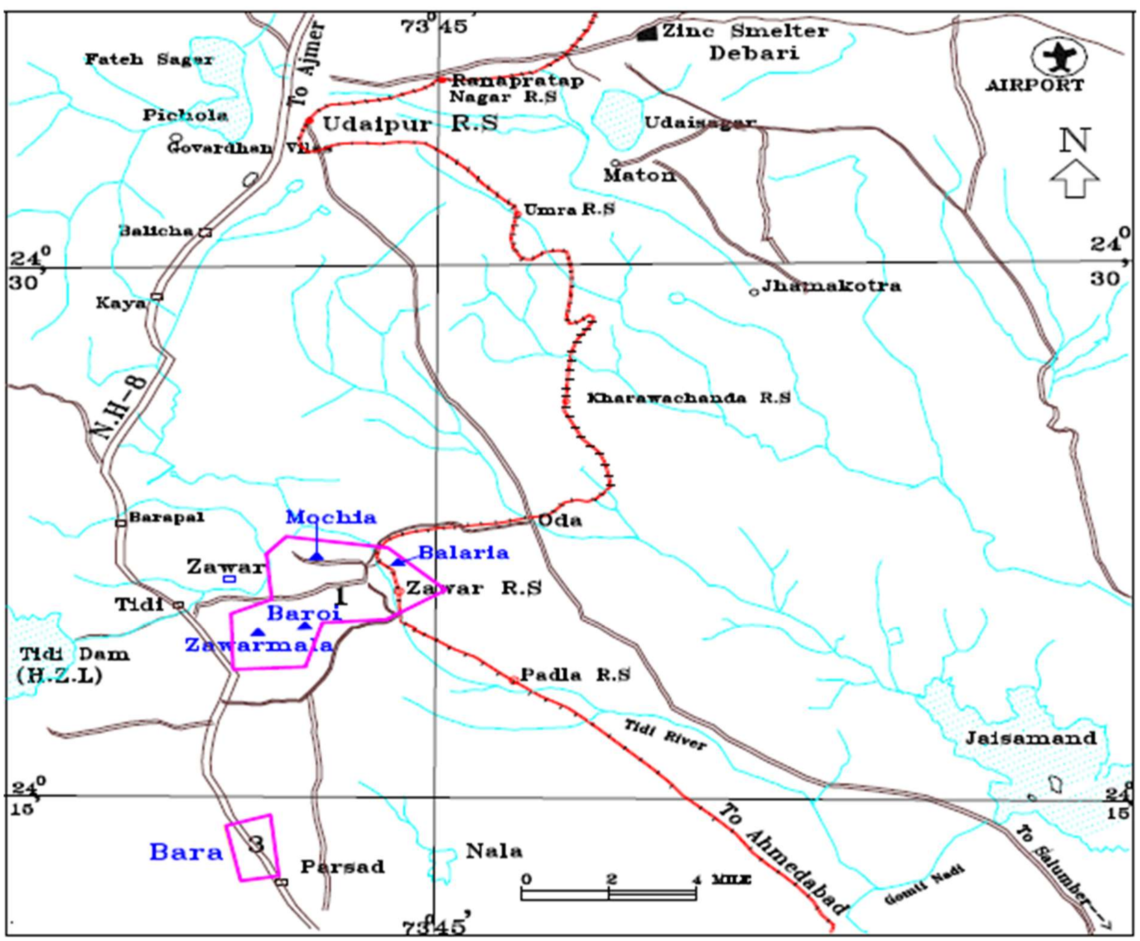


Figure 4: Zawar Mining Complex Locality Map

3.2 Mineral Titles, Claim Rights, Leases and Options

3.2.1 Lease agreements - Details

Table 6: Lease agreements - Details

Lease Details	Existing Mine
Name of the Mine	Zawar Group of Mines namely: 1. Mochia Lead Zinc Mine 2. Balaria Lead Zinc Mine 3. Zawarmala Lead Zinc Mine 4. Baroi Lead Zinc Mine 5. Bara Lead Zinc Mine
Lat/long of any boundary point	Pillar no1H (Latitude 24°22'12.78" Longitude 73°44'20.11")
Date of Grant of Lease	Initial – 01.04.1950 **IBM/421/2011**
Period/Expiry Date	Till 31.03.2030 as per Section 8A(5) of MMDR (Amendment) Act,2015

3.2.2 Lease agreements – Area

Table 7: Lease agreements - Area

Forest Land	Nil Ha	Non-Forest	Area (Ha)
		(i) Waste Land	1926.74
		(ii) Grazing land	nil
		(iii) Agriculture Land	155.35
		(iv) Protected Forest	1357.91
Total Forest	**Nil**	**Total Non- Forest**	**3620 Ha**

3.2.3 Lease agreements – District

Table 8: Lease agreements - District

District & State	Udaipur, Rajasthan
Taluka / Tehsil (Administration Area)	Sarada & Girwa
Village	Singatwara, Bhalaria
Whether the area falls under Coastal Regulation Zone (CRZ)	Not Applicable

3.3 Environmental Impacts, Permitting, Other Significant Factors and Risks

3.3.1 Commitments

No major commitments are allocated to the mining complex at this stage. Typical environmental monitoring and the annual permitting updates are the only legal commitments that mine needs to comply with

3.3.2 Security bonds

Bank Guarantee for degraded land has been submitted and reclamation plan submitted to IBM. In the submitted Mining Plan, the land under use has been reviewed and re-estimated for period 2020-25. Accordingly, proposed area put to use is 368. Ha, Thus the total amount of financial assurance is to be given ₹10,59,00,000/- (353 x 300000 per Ha) for the current proposal period.

Table 9: Security Bond calculation summary

Nomenclature	Area put on use at start of plan (In Ha)	Additional requirement during plan period (In Ha)	Total (In Ha)	Area considered as fully reclaimed & rehabilitated (In Ha)	Net area considered for calculation (In Ha)
Area under mining	36.63	9.73	46.36		46.36
Storage for top soil	0	0	0		0
Waste dump site(Stadium & Rock garden)	10.57	0	10.57	10.07	0.5
Mineral storage	3.95	0.78	4.73		4.73
Infrastructure – workshop, administrative building etc.	62.68	4.2	66.88		66.88
Roads	10.86		10.86		10.86
Railways	0	0	0		0
Tailing pond	107.63	74.89	182.52	35	147.52
Effluent Treatment Plant	0	0	0		0
Mineral Separation Plant	9.46	14.36	23.82		23.82
Township area	37.95	1	38.95		38.95
Community development	8.71		8.71		8.71
Other (CPP)	19.9	0	19.9		19.9
Grand Total	308.34	104.96	413.3	45.07	368.23

3.4 Royalties and Agreements

3.4.1 Joint ventures

The Zawar complex is not currently in a joint venture with other parties.

3.4.2 Royalty agreements

Lead & Zinc Concentrates are being produced and dispatched from the lease area to the smelters which are located outside the leased area, then royalty shall be chargeable on the processed product i.e., concentrate.

The Lead and Zinc Mineral royalty is to be paid based on London Metal Exchange or London Bullion Market Association price, the royalty shall be calculated at the specified percentage of the average sale price of the metal for the month as published by the Indian Bureau of Mines, for the metal contained in the concentrate of such mineral for the month.

The Rates of royalty declared as per Mine and Mineral (Development and Regulation) Act 1957 and royalty rates are:

1.The Royalty for Lead is 14.5% of London Metal Exchange lead metal price chargeable on the contained lead metal in the concentrate produced.

2. The Royalty for Zinc is 10% of London Metal Exchange Zinc metal price on ad valorem basis chargeable on contained zinc metal in the concentrate produced.

4 Accessibility, Climate, Local Resources, Infrastructure and Physiography

4.1 Topography, Elevation and Vegetation

4.1.1 Topography

The lease area falls on Survey of India GT sheet no. 45 H/11 & 15 and southern side of Udaipur district. The Zawar group of mines lease area consisting hilly terrain of variable heights ranging from 350mRL to 600mRL and marked by rugged and hilly terrain, dominated by steeply dipping outcrops and small valleys carved by the networks of ephimeral streamlets and streams. The drainage pattern is sub-dendritic to dendritic. The general slope of the area is from west to east and north-west to south-west. In the northern and western part of the area, there are some high peaks of the hills. The south-eastern part has comparatively lower elevation having lowest elevation, i.e., at Khakhadara. The major part of these hilly area is under forest cover. The total leasehold area (3620 Ha) is divided in two blocks – Block 1 & Block 3. The detail of general RL is given below -

Table 10: Lease area - size and elevations

	Lease area	Minimum RL	Maximum RL
Block 1	3172 Ha	345mRL	695mRL
Block 3	448 Ha	410mRL	540mRL

4.1.2 Drainage Pattern

The Tidi river forms major river system in Core and peripheral area. It is an ephimeral river and has two catchment zones in the north and west of the area. The northern catchment commences from the high peaks of mountains towards north-west and north-east of Kaya village. The stream from this area almost takes a south and south-easterly course and joins Tidi river at the base of a hill north-west of mine area.

The western catchment commences from high hilly peaks around Sera village. The Tidi river near Tidi and Zawar villages takes a meandering north-east course. After flowing almost west-east course, North- Northwest of mining area it changes its course towards south-east, where it is joined by Daya River. The Daya river emerges from hill area around Keora Khurd village. After flowing through hilly terrain as a narrow stream up to Rela village the downstream course of River broadens with thin deposits of coarse alluvium.

The Tidi river further south of the area, joins Gomti river which is tributary of Som River. The Som River joins Mahi River near Deola Village in Dungarpur District and after draining a part of eastern Gujarat ultimately joins Gulf of Cambey of Arabian Sea.

Highest Flood Level (HFL) recorded as 351.60 mRL recorded on 20.08.1994. All the mine entries Mochia (395.06 mRL), Balaria (378 mRL), Zawarmala (430.58 mRL) and Baroi (430.05 mRL) are above HFL

4.1.3 Vegetation

Composition of vegetation in the lease hold is uneven-aged, mixed, dry deciduous scrub and thorny forests. Vegetation is extremely irregular and varying considerably in condition, composition and density. Phytto-ecological structure of vegetation indicates three different strata, top, middle & ground. Top storey consists of Ailanthus execelsa, Azadirachta indica, Ficus bengalenis, Zizyphus zuzuba, Delonix regia, Albizzia lebbeck. Middle storey consists of Acacia nilotica, Cassia auriculata, Phoenix sylvestris, Prosopis julifora, Aegle marmeosis etc. The ground storey consists of Achyranthes aspera, Alternanthera sesselis, Argemone mexicana etc. The 4.3% of total lease area being used for agricultural purpose. The main crops grown in the study area are Wheat, Maize, Malt, Pulses, Cotton, Mustard and Rice. The 42% of total lease area is covered by protected forest land.

4.2 Accessibility and Transportation to the Property

Study area is served by road and rail network mostly. These villages are indirectly connected with major road and rail links via thin roads that merge into national and state highway in the region.

National Highway 48 and, State Highway 32 located in the study area. Other major road (metalled road) also passes evenly through the study area connecting many of the study area villages. Very few of these villages are still not connected with major road because of which villagers have to walk or either take bus that takes minimum 30 minutes to reach Jaitaran town. Bus service and auto service are also available in study area.

4.3 Climate and Length of Operating Season

4.3.1 Climate

Udaipur district lies on the south slope of the Aravalli Range of Rajasthan and has semi-arid type of climate. Dry climate prevails for most part of the year.

The mean daily maximum temperature is 39°C during May and mean daily minimum temperature is 10.8 °C during December. The annual mean temperature is 24.1 °C.

The climate of area is dry except for monsoon season. The Cold season is from December to February and is followed by summer from March to June.

Table 11: Summary - Climate Conditions

Temperature	Maximum 44.6 °C; Minimum 1.9°C
Relative Humidity	Maximum 82%; Minimum 25%
Wind Speed	2.6 to 11.7 kmph
Predominant Wind Dir.	NW, NNW, WNW

4.3.2 Rainfall Data

The average rainfall per year in the area ranges in 600-650 mm. The monsoon season is from July to September and is followed by post monsoon season in October & November. The minimum & maximum rainfall observed in last 10 years is 447mm and 873mm respectively.

Table 12: Summary - Annual Rainfall

Year	Total Rain fall (mm)	Year	Total Rain fall (mm)	Year	Total Rain fall (mm)
1991	670.00	**2001**	528.75	**2011**	872.85
1992	862.50	**2002**	622.10	**2012**	739.35
1993	527.25	**2003**	501.25	**2013**	740.80
1994	918.50	**2004**	712.75	**2014**	873.43
1995	416.55	**2005**	887.50	**2015**	529.04
1996	580.20	**2006**	1290.50	**2016**	719.00
1997	645.50	**2007**	493.00	**2017**	595.08
1998	620.50	**2008**	499.90	**2018**	508.00
1999	276.50	**2009**	446.85	**2019**	1240
2000	427.50	**2010**	744.45	2020	765.45

4.4 Infrastructure Availability and Sources

The Zawar Mines are situated approximately 44 km from Udaipur. HZL's total leasehold area is 36.20km^2, covering the four mines namely, Mochia, Balaria, Zawar Mala, and Baroi and the integrated concentrators. Access from Udaipur is via N.H-8 which crosses the southern tip of the property.

The current Zawar processing plant processes ore from the Mochia and Balaria mines which are located adjacent to the plant through a truck decline and conveyor decline respectively. Ore from the remote Zawarmala (8 km) and Baroi (6 km) mines is transported by road to the plant. The original Zawar plant is more than 25 years old and employs two separate crushing and grinding streams feeding a common flotation circuit for the production of a bulk concentrate. The mine has also built a second new plant adjacent to the original facility that together increases capacity to 4.5 Mtpa.

HZL operate an 80 MW coal fired CPP to supply power for the Zawar plant. The plant is remote from the Zawar site and power is transmitted via the national electricity grid system. Boiler ash from the CPP is also stored in the Zawar TSF and CPP fly ash is sold.

Of the 80 MW available supply, the current mine operation consumes around 10 MW, and this is expected to increase to 35 MW once the envisaged plant expansions are implemented. Power consumption for the plant is reported to be approximately 20 kWh/t. Excess power is reportedly sold to the grid. A diesel-powered generation plant capable of 6 MW is installed at the Zawar site as emergency power for the mining and processing operations.

The majority of the water make up requirement is supplied from underground dewatering with additional water available from a nearby dam located around 12 km from the plant. This dam is owned by HZL. Underground water is not treated prior to use in the plant. Historically, plant tailings were not thickened, and all water was returned from the dam. Once the new tailings thickener is operational water will be recirculated from the thickener overflow with a smaller amount returned from the tailings dam for reuse on the plant. Net water consumption is reported to be around 0.5 m^3/t and water supply is reported not to be a problem especially with the large water storage dam available. All concentrates and supplies are transported by road.

5 History

5.1 Historical Exploration and Production

The original Mining Lease was granted by Rajpramukh, Rajasthan in favour of Metal Corporation of India over an area of 5,178 ha in five blocks 1,1A,2,3 & 4 on 18th August 1950, valid until 1970.

In the First Renewal of the Mining Lease, valid until 1990 was approved by the Govt. of Rajasthan in favour of Hindustan Zinc Limited on 16.01.1975. A Second Renewal, valid until 2000 was granted to HZL in 1992.

Due to low mineralization potential, HZL decided to reduce the lease hold area from 5,178 to 3,620 ha, by surrendering an area of 1,558 ha. This was confirmed in August 1999 and the lease extended until 2010, by the Govt. of Rajasthan. In February 2015, The Department of Mines & Geology of the Government of Rajasthan extended the lease validity until March 2030 as per Section 8A (5) of MMRD (Amendment) Ordinance 2015, dated July 2016.

The exploration by HZL started in 2005 with 196 boreholes underground for a total of 6,018 m and by 2021, they had completed 10,438 boreholes for a total of 744,973 m. The exploration drilling from surface started in 2007 with one borehole to a depth of 1,510 m and by 2021, they had completed 572 boreholes for a total of 426,005 m.

Production is steadily increasing from 1.77 Mt in 2017 to 3.95 Mt in 2021.

Table 13: Zawar Exploration Drilling

Year	Surface Exploration		Underground Exploration	
	No. of Bore holes	Drill Depth (m)	No. of Bore holes	Drill Depth (m)
Jun-05	-	-	196	6,018
Jul-06	-	-	302	11,561
Aug-07	1	1,510	578	19,901
Sep-08	26	15,425	352	15,606
Oct-09	22	16,021	397	18,329
Nov-10	14	11,778	45	1,730
Dec-11	36	20,358	89	2,417
2012-13	38	18,967	315	9,782
2013-14	77	37,267	736	39,142
2014-15	49	34,851	972	41,795
2015-16	38	40,662	768	39,253
2016-17	35	39,156	740	51,377
2017-18	41	39,616	1,348	83,611
2018-19	55	58,887	1,239	98,749
2019-20	106	76,381	1,239	151,018
2020-21	53	35,209	1,122	139,438
Totals	**591**	**446,088**	**10,438**	**729,727**

Table 14: Zawar Production 2017 – 2021

Description	Units	F2017 Actual	F2018 Actual	F2019 Actual	F2020 Actual	F2021 Actual
Mochia	Mt	0.41	0.62	0.95	1.18	1.42
Balaria	Mt	0.42	0.47	0.58	0.49	0.73
Zawarmala	Mt	0.34	0.34	0.33	0.42	0.4
Baroi	Mt	0.6	0.74	1	1.18	1.4
Ore mined	Mt	1.77	2.18	2.86	3.27	3.95
Ore processed	Mt	1.46	2.06	2.9	3.29	3.95
Zn grade	%	2.73	2.48	2.41	2.52	2.48
Pb grade	%	2.12	2	1.93	1.94	1.83
Ag grade	g/t	41.3	40.9	38.9	39.9	29.4
Zn recovery	%	90.2	78.6	78.2	86.3	90.6
Pb recovery	%	90.5	75.1	80.2	84	86.1
Ag recovery	%	77.3	57.8	57.2	66.5	70
Zn MIC	kt	37	40	55	72	89
Pb MIC	kt	28	31	45	54	62
Ag MIC	koz	1,499	1,404	1,717	2,381	2,653

6 Geological Setting, Mineralization and Deposit

6.1 Regional Geology

The Zawar lease area is situated in the NW-SE trending hills of Rajasthan and is of Paleo-Proterozoic age (1700-1800 Million Years). The lithological sequence comprises of meta-sedimentary rocks, overlying a basement (Sarara Inlier) contemporary to BGC (Banded Gneissic Complex) of Rajasthan. The Central & Western part of the Udaipur district is occupied by the younger formation of Aralvali supergroup & Delhi supergroup of Proterozoic age. Quaternary and recent alluvium overlies most of the formations in isolated patches, along river courses and in the shallow depressions. The stratigraphic succession of the district is as follows:

Table 15: Zawar Regional Stratigraphy

Age	Supergroup	Group	Lithology
Proterozoic	Delhi Supergroup	Gogunda Group	Calc-schists, gneisses, mica-schists, garnetiferous biotite-schists, quartzites & migmatites
	Rikhabdeo Ultramafic suite		Serpentinite, talc-chlorite-schist, actinolite-tremoliteschist & asbestos
	Aravalli Supergroup	Jharol group	Chlorite-mica schist, calc schist & quartzite
		Bari lake group	Meta volcanics, chlorite schists, amphibolite, quartzite& conglomerate
		Udaipur group	Phyllite, mica schists, meta siltstone, quartzite, dolomite, gneisses & migmatites`
		Debari group	Meta arkose, quartzite, phyllite, dolomitic marble &dolomite
---unconformity ---			
Archean	Bhilwara Supergroup	Mangalwar complex	Migmatites, gneisses, quartzite, felspathic garnet ferrous mica schists & para Amphibolites

6.2 Property Geology

All the deposits at Zawar are hosted by epizonal metamorphosed dolomites of the Tiri Formation, Aravalli Supergroup (1.7 – 1.8 Ma), either in north-south structures (Post-Aravalli orogeny) or in W-E structures (Delhi orogeny). The mineralisation comprises sphalerite and galena as disseminations or veinlets in bodies defined by grade contacts only. Silver mineralisation has been concentrated in the upper levels of the mines which have been depleted either by historical mining of earlier modern mining.

The deposits are either tabular, steeply northeast-dipping and west-plunging (Mochia and Balaria), or complex-shaped lenses following the Northern plunge of a fold-axis (Zawarmala).

At Baroi, mineralisation is largely disseminated and organised in poorly constrained Northwest dipping bodies.

The deposits are considered to be syn-metamorphic stratabound carbonate-hosted (dolomite) lead-zinc deposits (Mississippi Valley Type in the wider sense). There are minor cross cutting post-mineralisation intrusives of Precambrian and Cretaceous age. The deposits have the following general geometry:

- Mochia Central: strike: 1,050m E – W, consisting of 8 lenses; lenses strike 60 - 200m; Dip 80-85º towards the S; Width 2-45m; dominant plunge of 50-60º towards the SW.
- Mochia West: strike: 1,800m E – W, consisting of 32 lenses; lenses strike 60 – 150m; Dip 80-85º towards the S; Width 2 – 20m; dominant plunge of 50-60º towards the SW.
- Balaria Central: strike: 1,050m NW – SE, consisting of 21 lenses; lenses strike 60 – 200m; Dip 70º towards the SW; Width 2 – 40m; dominant plunge of 50-60º towards the SW.
- Balaria West: strike: 1,800m WNW – ESE, consisting of 15 lenses; lenses strike 60 – 200m; Dip 70º towards the NW; Width 2 – 10m; dominant plunge of 50-60º towards the SW.
- Zawarmala: strike: 550m NW – SE, consisting of four lenses; lenses strike 60 – 200m; Dip 70º towards the SW; Width 2 – 40m; dominant plunge of 30-60º towards the NW.
- Baroi Central: strike: 1,200m NW – SE, consisting of 12 lenses; lenses strike 60 – 250m; Dip 70º towards the NW; Width 2 – 20m; dominant plunge of 50-60º towards the NW.
- Baroi North: strike: 1,300m NW – SE, consisting of 9 lenses; lenses strike 100 – 120m; Dip 50-60º towards the NW; Width 2 – 15m; dominant plunge of 50-60º towards the NW.

Block 1 is a conglomeration of four deposits Mochia, Balaria, Zawarmala & Baroi situated in a complexly folded geological structure. All the deposits are hosted in meta-sedimentary sequence for base metal mineralization. Host dolomite is flanked by greywacke, phyllite on south and phyllite & quartzite on the north. Stratigraphically, the rocks of the mine area form part of Mandli, Baroi Magra and Zawar formations of Tiri Series in the regional stratigraphical sequence. Generalized succession of the deposit is shown below.

Table 16: Zawar Local Stratigraphy

Series	Formation	Member	Litho Unit
			Quartz and quartz-felspar veins, metadolerite dykes
--unconformity --			
Tiri Series	Zawar Formation	Haran Member	Upper Phyllite, Quartzite
	Baroi Magra Formation	Mochia Member	Dolomitic quartzite, pure dolomite, siliceous dolomite (Host rock), sub-greywacke (?), argillaceous quartzite and interbedded phyllites
	Mandli Formation		Greywackes

Complexly folded geological structure formed out of two distinct periods of tectonic activities (Post Aravalli & Post Delhi orogenies).

- Zawar Mala & Baroi occupy original northerly plunging structure generated out of Post Aravalli orogeny.
- Mochia & Balaria occupy east-west trending & westerly plunging cross folded anticlinorium modified by subsequent post Delhi orogeny.
- Bara prospect is located on the south extension of dolomite limb of northerly plunging Zawar Mala – Baroi folded structure. The host rock is subjected to intricate multi phased folding.

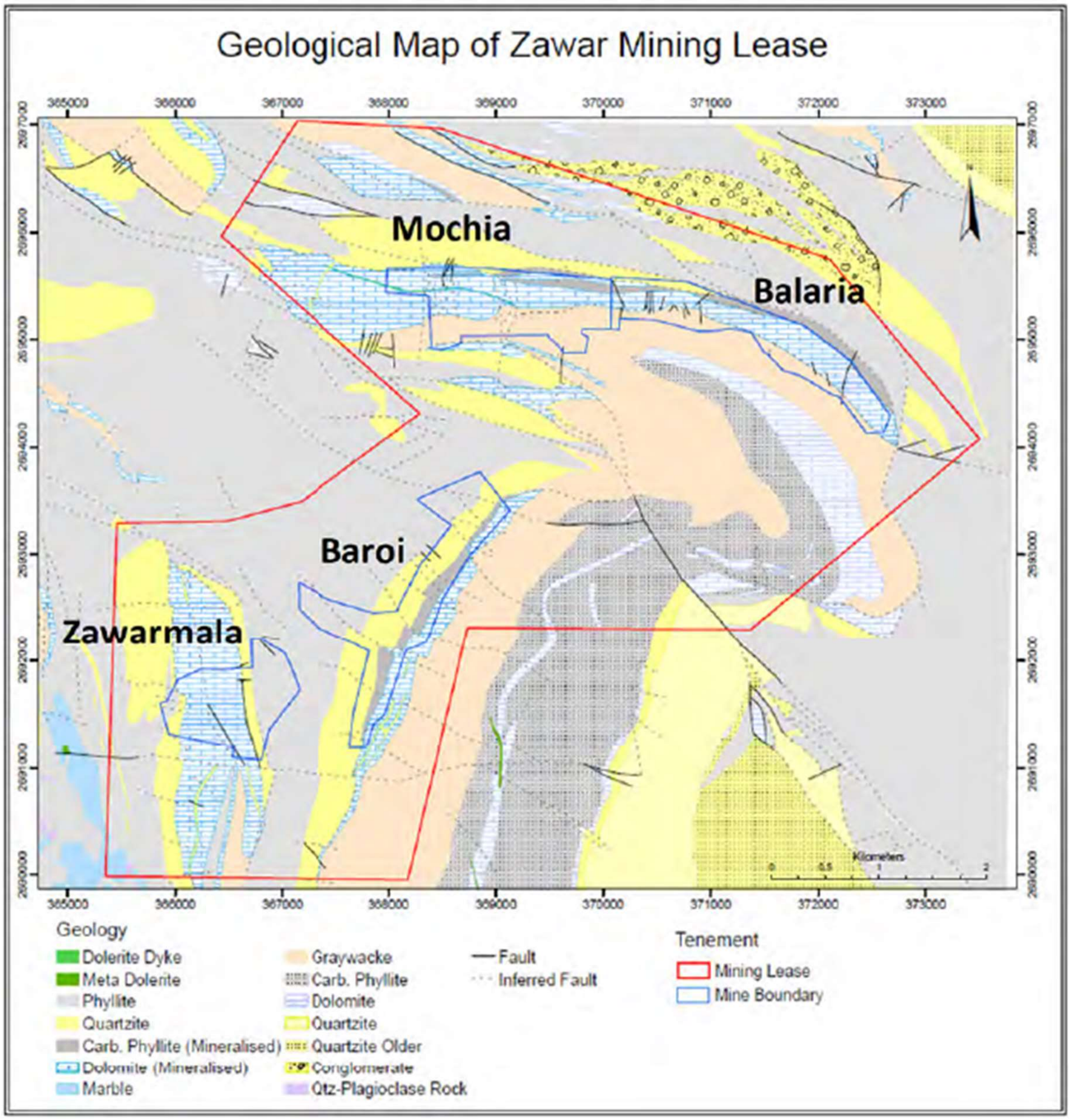


Figure 5: Geological Map

6.3 Deposit Types

The mineralization in the lease hold area is in the form of echelon & fracture filled structures due to which the orebody shows pinching and swelling in both dip and strike directions. The initial delineation of the orebodies by surface drilling and underground exploratory drilling, usually differs from the later stage (After definition Drilling) delineation which also includes underground mapping and correlation. By virtue of exploiting the deposit during the last few decades, the general trend of variation found to be positive. The reserves of the delineated orebodies after the definition drilling, usually from the developmental drives, is always found to be larger than the resource of the orebody when it was delineated from surface exploration.

6.4 Mineralization

Base metal sulphide deposits occur throughout Zawar, solely within the dolomitic horizon of the Baroi Magra formation. Most of these occurrences are manifested at the surface by ancient workings in the form of long-abandoned trench mines, circular shafts and inclines. These usually penetrate for a few tens of metres in depth but some of the early workings in Zawar Mala, Balaria and Mochia do extend for more than 100 m vertical depth. The ancient mines systems give much information to the mining geologist concerning the shape, size and attitude of the exploited or explored ore lenses and of the deposits below the surface, but they give little data on the grade of the ore mined in the past or of the depth extension of mineralization. Salient aspects of four deposits of Zawar Lease Block 1 are:

- Host Rock. Carbonate sequence (dolomites & its facies variants) belonging to Mochia member overlying a rhythmic succession of greywacke, phyllite & quartzite.
- Genesis & Control of Mineralization. Stratiform & strata bound, has undergone transformation & re-mobilization under low temperature conditions.
- Mochia & Balaria. Galena (Pb ore) & sphalerite (Zn ore) veins and veinlets concentrate into E-W to NW-SE trending, steeply dipping & westerly plunging tabular ore bodies with a width ranging from 2 m to 45 m.
- Zawar Mala. Mineralization is concentrated at the core of the anticline and follows the axial plane of the fold plunging 40° due North.
- Baroi. Disseminated Pb & Zn mineralization is in the form of NE-SW trending tabular ore bodies dipping NW and plunging to the West.

The main ore minerals at Zawar are, in order of abundance: sphalerite, pyrite and galena, although at Baroi, galena is the predominant base metal sulphide mineral. All Zawar ore is indicated to be “clean” and easy to liberate with minimal level of metal impurities or other contaminants reporting into the concentrates. The base metal sulphides are indicated to be mainly associated with the gangue minerals and can be liberated at relatively coarse size with little intergrowth of the lead and zinc minerals. Cadmium is reported to occur with sphalerite while silver occurs predominantly in solid solution with galena.

The feeds are blended for treatment as available to achieve the plant feed. Grades from the different mines vary with Baroi containing relatively high lead compared to the other mines, which are zinc-rich. Plant feed grades are reportedly typically 3.5-4.5%Zn and 1.8-2.2%Pb. Pyrite levels in the feed are around 5-6%, with silver around 30-45 g/t Ag. Typical base metal feed grades for the individual mines re reported to be;

- Zawarmala: 3 – 3.5% Zn, 1.5 – 2% Pb;
- Balaria: 5 – 6% Zn, 1% Pb;
- Baroi: 1.5% Zn, 4.5% Pb;
- Mochia: 4 – 5% Zn, 1.5% Pb.

The mineralogy of the different feeds is reported to be generally similar. The ores are also reported to be moderately soft with a BWI in the range of 11 to 12 kWh/t.

- Host Rock. Carbonate sequence (dolomites & variants) belonging to the Mochia member overlying a rhythmic succession of greywacke, phyllite & quartzite.
- Genesis & Control of Mineralization. Stratiform & strata bound, has undergone transformation & re-mobilization under low temperature conditions.
- Mochia & Balaria. Galena (Pb ore) & sphalerite (Zn ore) veins and veinlets concentrated into E-W to NW-SE trending, steeply dipping & westerly plunging tabular ore bodies having a width ranging from 2 m to 45 m.
- Zawar Mala. Mineralization is concentrated at the core of the anticline and follows the axial plane of the fold plunging 40° due North.
- Baroi. Disseminated Pb & Zn mineralization is in the form of NE-SW trending tabular ore bodies dipping due NW and plunging due West.

7 Exploration

The HZL complex has undergone extensive exploration since their discovery in the mid-1970's. In the past few years, exploration has been undertaken by means of diamond drilling underground for two purposes, namely grade control and extension of current mineral envelopes to deeper levels.

7.1 Summary of Exploration Activities

In general, the underground exploration drilling is undertaken during the underground mining activities. On-reef drilling is carried out by the mine and constitutes the majority of the meterage drilled.

Table 17: Summary of Exploration Drill for HZL Complex (2017-2022)

Mine/Deposit	F2017		F2018		F2019		F2020		F2021		F2022
	No. Holes	(m)	No. Holes	(m)	No. Holes	(m)	No. Holes	(m)	No. Holes	(m)	(m)
Rampura Agucha	30	10 443	64	7 056	189	27 458	246	32 124	216	30 234	53 500
Kayad	100	16 154	75	46 365	90	46 891	118	37 371	199	44 950	83 000
Rajpura Dariba	37	15 598	89	10 838	168	32 435	203	34 717	98	27 639	43 200
Sindesar Khurd	288	72 912	606	112 906	643	111 824	604	106 670	446	76 657	135 675
Zawar	280	89 550	1 268	126 413	1 292	157 666	1 062	200 032	1 165	177 029	209 700
Bamnia Kalan	0	0	5	3 615	62	28 184	52	25 682			
TOTAL	**735**	**204 657**	**2 107**	**307 193**	**2 444**	**404 458**	**2 285**	**436 596**	**2 124**	**356 509**	**525 075**

7.2 Exploration Work

In summary, the exploration data for the Zawar deposit group comprises pre-1985 historical surface exploration data comprises some 107,620m of drilling information as well as more recent drilling. Up to F2022 over 7,500 drillholes for over 950 km have been drilled.

7.3 Drilling Technique, Spatial Data & Logging

HZL is employing directional drilling techniques and can drill several deflections from one master hole. Drilling is generally in NQ core diameter. Drill core appears to be of extremely high quality with excellent recovery, which is only slightly reduced in faulted/sheared areas. Core recovery is excellent averaging some 95%.

Gyroscopic downhole surveys are completed using a multi-shot camera (Reflex). Surface Drill Collars are initially located on ground using GPS. Subsequently, these are tied up with Local Grid by the mine survey team using Total Station. Down-hole direction arrows are marked on every core piece by the driller. Similarly run ends and meter pegs are neatly marked and placed. Meter depth is also painted on the core just before the peg. Geologists ensure that run pegs are at the correct locations. UG mine workings are surveyed using Total Station.

Logging practices are adequate for resource estimate purposes. Almost all of the available core, particularly within 100m of the deposit extents on the hanging wall and up to the end of the holes on the footwall side, has been photographed using a digital camera. Only the most basic geotechnical

parameters are collected. Geological and geotechnical logging is undertaken on a systematic basis by HZL geologists. All data is logged in hardcopy and entered in to excel before being input into the central database, which is securely stored and backed-up at the office in Udaipur.

Logging is largely qualitative. Certain semi-quantitative metrics are logged: structural data, RQD, fracture frequency and model mineral percentages. Core is well logged and interpreted by competent geologist's onsite. Limited geotechnical data was recorded.

Note: *Recommend more detailed geotechnical logging and recording of structures*

7.4 Sample Preparation

The following sample splitting and preparation methods are employed:

- 1m length core samples in the visible mineralised zones.
- Separate samples for notably different core recoveries in two contiguous runs.
- Separate samples for visibly significant grade variations (Zn and / or Pb).
- Longitudinal split line is marked along the marked sample so as to ensure equal division of ore portion in the two halves.
- Samples are clearly labelled and there is good control of samples through the preparation and analytical process

Note: *Sample preparation is performed diligently and in line with best practices. The dispatch and sample control systems was observed on site.*

7.5 Sample Analysis and QAQC Protocols

Samples are analysed for the following metals:

- Pb, Zn, Fe, Cd, Cu, Co, Sb, Bi, Ni and Mn

by 4-acid digest and ICPOES finish. Ag and As by aqua regia digestion followed by AAS finish.

The primary analytical laboratory, Shiva, introduces its own standards at 1 in 30 samples and repeats the analysis for our every 10th sample. Sample preparation is undertaken by accredited Shiva Analytical Pvt Ltd, Bangalore.

In accordance with the HZL's QA/QC programme consists of:

- Insertion of blank material (quartz/pegmatite) into the numbered sequence as the first sample at the beginning of the mineralization in each sample batch.
- Systematic insertion of certified reference material ("CRM")(GESTAT and OREAS) at frequency of 1 in 25. The choice of CRM is at the discretion of the logging Geologist.

- Random insertion of duplicate pulp checks, at a frequency of 1 in 10.
- Annual umpire assay in HZL's laboratory at ZAW.

QA/QC procedures are adequate and no significant deviations have been reported since 2004.

8 Mineral Processing and Metallurgical Testing

The HZL has a network of operations across India and ZAW is currently an operating mine with a working CPP with many years of operations behind them. The mineral processing is well understood and there is no need to conduct any metallurgical test work at the current operations.

9 Mineral Resource Estimate

9.1 Introduction

The Mineral Resources described in this Item are based on appropriate geoscientific information, economic and technical parameters, and grade and tonnage estimation processes. The Mineral Resource estimates were determined using Inverse Distance Weighting to the power of two (IDW^2) statistical methodology at Zawarmala and Ordinary Kriging (OK) at Mocia, Baroi and Balaria. Considered sample lengths, grade capping / cutting, the spatial distribution of drill holes and the quality assurance and quality control results for the analytical sample grades determined. Geological modelling and grade estimation used Datamine software.

9.2 Geological Models

The zinc (Zn) and lead (Pb) sulphide, and silver (Ag) mineralization at Zawar is understood to be a syn-metamorphic strata bound carbonate-hosted (dolomite) deposit akin to a Mississippi Valley deposit type. The deposit has been cross-cut by Precambrian and Cretaceous age intrusive post-mineralisation. The dolomites are part of the Tiri Formation, Aravalli Supergroup, which has been disrupted by Post-Aravalli Orogeny north-south structures and by west-east structures related to the Delhi Orogeny. The surrounding rock types to the Zawar deposits are greywacke, phyllite, dolomites, and quartzite. A total of four mineralized deposits are known at Zawar, namely Balaria, Baroi, Bara, Mochia and Zawarmala.

At Balaria and Mochia the mineralization is in the form of tabular overlapping veins and en-echelon fracture filling veins which dip steeply to the northeast with a westly plunge. The Baroi deposit is largely disseminated mineralization which is poorly constrained as northwest dipping bodies. Structurally complex lenses following a north plunging fold axis comprise the Zawarmala deposit.

Baroi is subdivided into the Central and North deposits, whilst Mochia consists of the Mochia Central and West deposits. Balaria consists of the Central and West deposits. The Balaria, Mochia, Baroi and Zawarmala deposits consists of several lenses:

- Mochia Central: eight lenses between 2 - 45 m in width
- Mochia West: 32 lenses between 2 - 20 m in width
- Balaria Central: 21 lenses between 2 – 40 m in width
- Balaria West: 15 lenses between 2- 10 m in width
- Baroi Central: 12 lenses between 2 - 20 m in width
- Baroi North: nine lenses between 2 - 15 m in width
- Zawarmala: four lenses between 2 - 40 m in width
- Bara: one lense between 2 - 16 m in width.

The strike, dip, dip direction and plunge of the deposits are:

- Mochia Central: a strike length of ~1,800 m E-W and dipping at 80^o to 85^o to the south. The dominant plunge angle is 50^o to 60^o to the SW
- Mochia West: a strike length of ~1,050 m E-W and dipping at 80^o to 85^o to the south. The dominant plunge angle is 50^o to 60^o to the SW
- Balaria Central: a strike length of ~1,050 m NW-SE and dipping at 70^o to the SW. The dominant plunge angle is 50^o to 60^o to the SW
- Balaria West: a strike length of ~1,800 m WNW to ESE and dipping at 70^o to the NW. The dominant plunge angle is 50^o to 60^o to the SW
- Baroi Central: a strike length of ~1,200 m NW-SE and dipping at 70^o to the NW. The dominant plunge angle is 50^o to 60^o to the NW
- Baroi North: a strike length of ~1,300 m NW-SE and dipping at 50^o to 60^o to the NW. The dominant plunge angle is 50^o to 60^o to the NW

- Zawarmala: a strike length of ~550 m NW-SE and dipping at 70° to the SW. The dominant plunge angle is 30° to 60° to the NW
- Bara: a strike length of ~1,150 m N-S dipping at 80° to the west. The dominant plunge angle is 40° to the north.

The primary sulphide minerals are sphalerite (ZnS) and galena (PbS), as well as silver-bearing minerals. The deposits all demonstrate Zn and Pb grade continuity except for Zawarmala, where the grades are highly variable due to a local and highly complex folded structure.

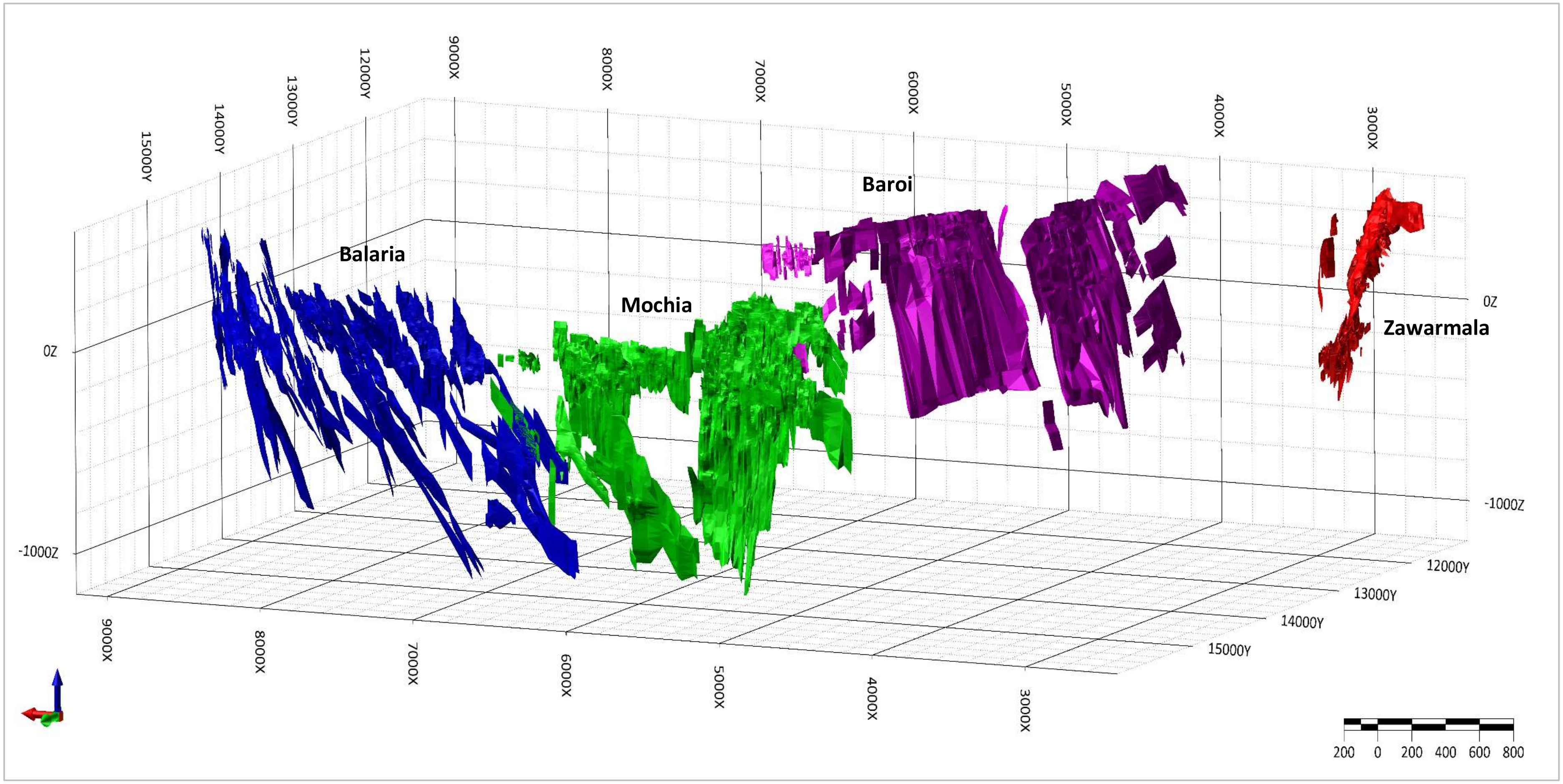


Figure 6: 3D Representation of the Zawar deposits

9.3 Block Model Orientation and Dimensions

The wireframes were constructed using cross-sections taken across the ore body with principal sections on a 100 m spacing and infill sections at 50 m, 25 m and 12.5 m. A geological cut-off of 3% Zn + Pb cut-off over a 3 m minimum thickness defined the limits of the mineralized zones.

The wireframes were filled with a block model based on a parent-block size of 10 x 5 x 10 m (across-strike (X) / along-strike (Y) / vertical height (Z)) for areas covered by close-spaced underground drilling, and 30 x 50 x 30 m in less well drilled area. Appropriate sub-blocking has been used at mineralisation contacts to honour the geometry and volume.

9.4 Database

The database used for the grade estimates is based on data received from Hindustan Zinc Limited from their Acquire Database system. A total of 8,870 drill holes were available for use in generating the wireframes, and grade and tonnage estimates. The cut-off date for the database for used in the Mineral Resource estimation process is F2021. The drill hole data before 1985 comprises 107,620 m of drilling whilst 1,150 km of drilling occurred up to F2021. The surface drill holes have an average grid spacing of 25 x 25 m with infill drilling between 12.5 m up to 50 – 100 m.

ABGM has reviewed the drill hole database from 2004 to F2022 and concluded that the drill hole data is adequate for use in the Mineral Resource estimation process. The pre-1985 drill holes were found to have adequate industry standard quality assurance and quality control (QAQC) quality assurance programmes and procedures which allowed for replication, precision and accuracy of the sample grades. The reader is directed to Item 8 for sample preparation, analytical techniques and security.

9.5 Exploratory Data Analysis

Table 1-1 summarizes the classical statistics of the sample population distributions per deposit.

Table 18: Classical statistics for the zones

Deposit	Metal	Minimum	Maximum	No. of Points	Mean	Median	Coeff. of Variation
Balaria	Zn (%)	0.00	50.53	31,998	5.77	3.68	1.10
Baroi	Zn (%)	0.00	49.83	17,413	1.72	0.42	2.01
Mochia	Zn (%)	0.00	207.00	28,690	3.80	2.59	1.12
Zawarmala	Zn (%)	0.00	74.95	13,631	4.99	3.30	1.08
Balaria	Pb (%)	0.00	58.18	31,315	1.31	0.12	2.60
Baroi	Pb (%)	0.00	79.00	17,413	3.15	1.50	1.57
Mochia	Pb (%)	0.00	75.00	28,690	2.24	0.33	2.21
Zawarmala	Pb (%)	0.00	67.80	13,632	2.28	0.18	2.57
Balaria	Ag (g/t)	0.00	2,148.00	27,419	16.78	1.00	3.66
Baroi	Ag (g/t)	0.00	5,460.00	11,189	43.16	18.00	2.59
Mochia	Ag (g/t)	0.00	1,720.00	13,613	26.51	9.00	2.50
Zawarmala	Ag (g/t)	0.00	2,025.00	7,328	28.32	9.00	2.59

Normal space histograms for the ZAW drill hole samples represent strongly skewed distributions indicating that the mean is greater than the median value which is greater than the mode. This indicates that the mean value is influenced by higher grade values.

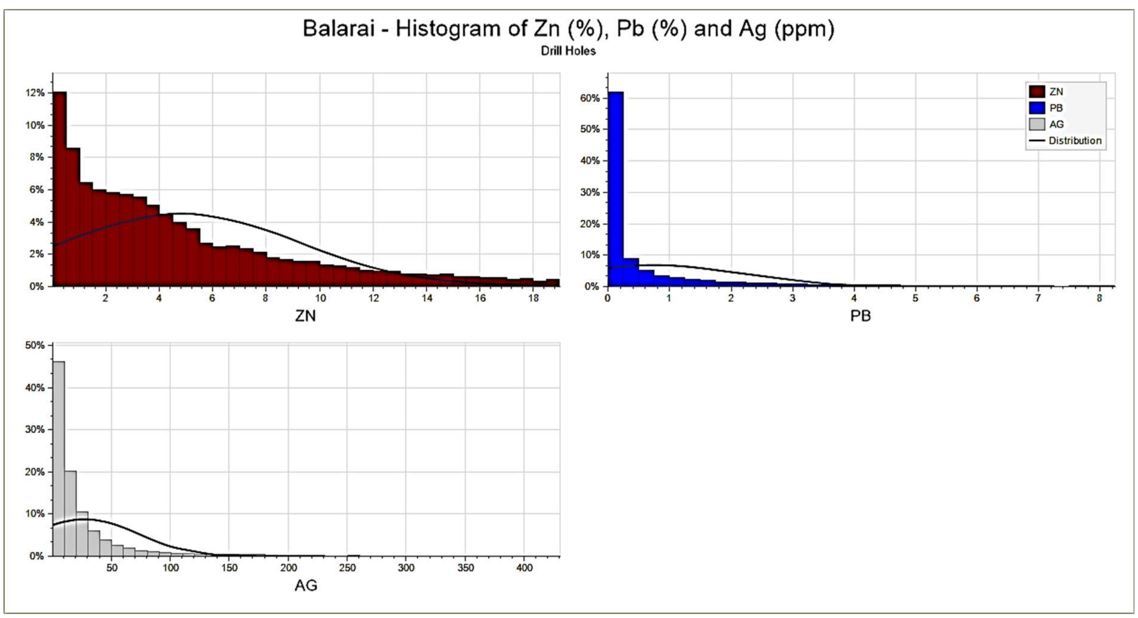


Figure 7: multi-variate histograms of the ZAW drill hole samples for Zn (%), Pb (%), and Ag (g/t)

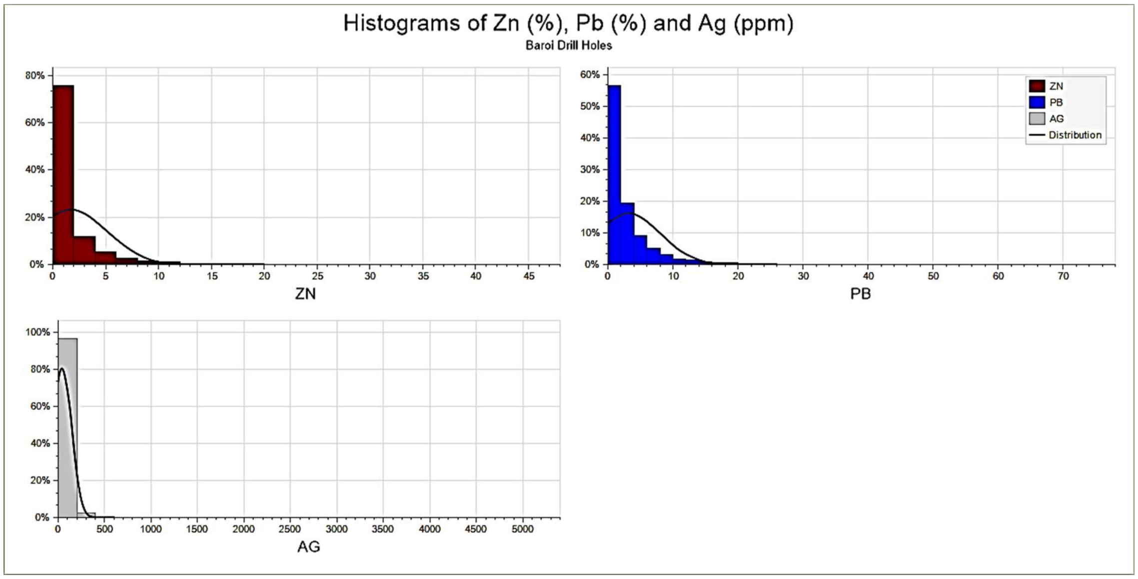


Figure 8: multi-variate histograms of the Baroi drill hole samples for Zn (%), Pb (%), and Ag (g/t)

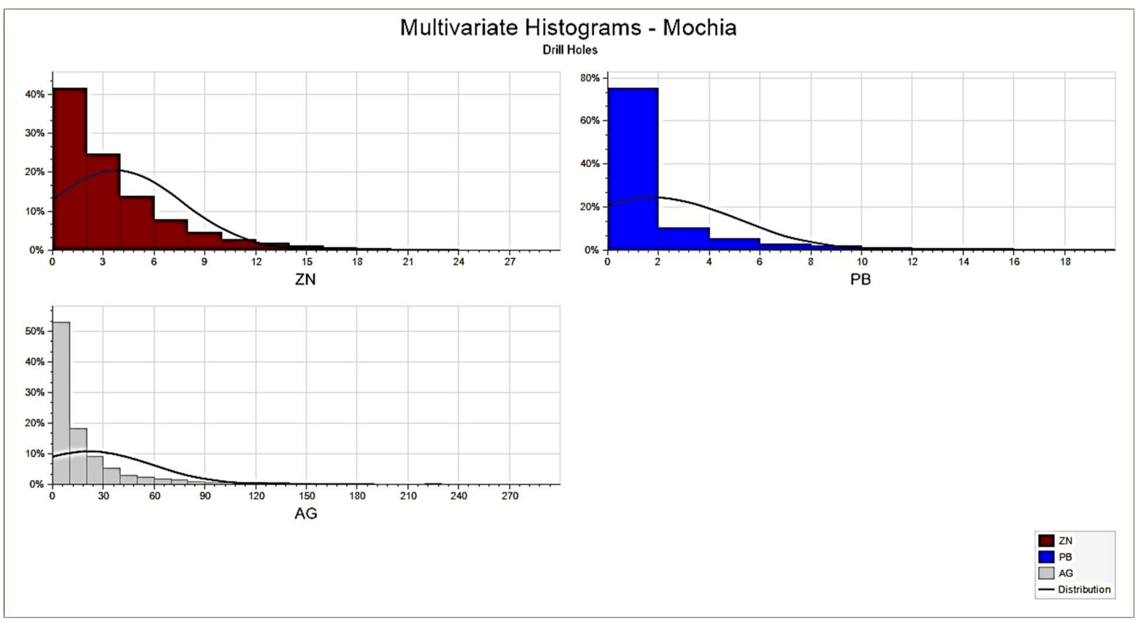


Figure 9: multi-variate histograms of the Mochia drill hole samples for Zn (%), Pb (%), and Ag (g/t)

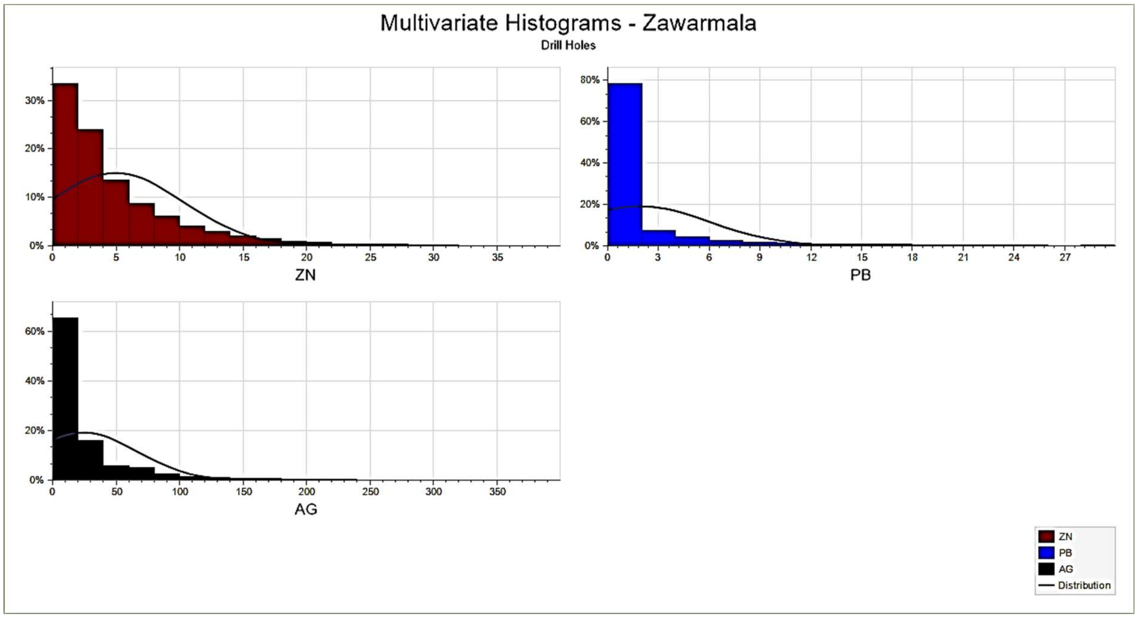


Figure 10: multi-variate histograms of the Zawarmala drill hole samples for Zn (%), Pb (%), and Ag (g/t)

9.6 Data Compositing

Most of the drill hole samples are 1.0 m in length and were therefore composited to 1.0 m lengths. Data compositing reduces the data population variability and contributes to a more uniform data support for estimation purposes. The drill hole and composite data populations correspond with each other for the normal space histograms drill hole samples demonstrating the data population distribution has been maintained.

9.7 Bulk Density Determination

Bulk densities were analysed using the Archimedes' Principle methodology. The Archimedes' Principle measures the weight / volumetric displacement of a sample within air and water. The correlation between the values reconciles well against production data. The density data was interpolated during the geostatistical estimation process. Where the density values between metal and density values is well established the bulk density is derived from multi-linear regression formulae for Zn and Pb.

The formula for Balaria is:

Density (t/m^3) = (0.0274 * TMC) + 2.8563 where TMC is the total metal content of Zn and Pb.

The formula for Baroi is:

Density (t/m^3) = (0.0209 * TMC) + 2.8255 where TMC is the total metal content of Zn and Pb.

The formula for Mochia is:

Density (t/m^3) = (0.0206 * TMC) + 2.8078 where TMC is the total metal content of Zn and Pb.

The formula for Zawarmala is:

Density (t/m^3) = (0.0393 * TMC) + 2.8059 where TMC is the total metal content of Zn and Pb.

9.8 Grade Capping / Cutting

Grade capping and cutting removes outlier values which will unduly influence the variability in the estimation process. Outlier values were determined via statistical analyses. Cutting removes the values above a threshold whilst capping converts the outlier values to the threshold value.

Grade capping applied at Balaria:

- Zn: 20%
- Pb: 5 - 30%
- Ag: 100 - 200g/t.

Grade capping applied at Baroi:

- Zn: 10 - 30%
- Pb: 10 - 50%
- Ag: 100 - 200g/t.

Grade capping applied at Mochia:

- Zn: 15 - 50%
- Pb: 15 - 60%
- Ag: 100g/t.

Grade capping applied at Zawarmala:

- Zn: 50%
- Pb: 50%
- Ag: 300g/t.

9.9 Reasonable Prospect of Eventual Economic Extraction and Cut-offs

Mineral Resources must demonstrate reasonable prospects for eventual economic extraction (RPEEE). Consideration of geological, mining engineering, processing, metallurgical, legal, infrastructural, environmental, marketing, socio-political and economic assumptions used should satisfy that the project is economically viable eventually.

At Zawar confidence can be placed on the geological understanding and models, the mining methods and planning as well as the understanding of the metallurgy, processing legal, infrastructural, environmental, marketing, socio-political and economic assumptions. The reader is referred to the relevant Items within this report for detail and opinions.

The cut-off grades (COGs) applied to the Mineral Resources are stated on a Zn equivalent (ZnEQ) basis for Balaria, Baroi, Mochia and Zawarmala:

- Balaria 3.36%; ZnEQ = Zn + (0.601 x Pb) + (0.02687 x Ag)
- Baroi 2.56%; ZnEQ = Zn + (0.601 x Pb) + (0.02688 x Ag)
- Mochia 2.67%; ZnEQ = Zn + (0.601 x Pb) + (0.02687 x Ag)
- Zawarmala 3.44%; ZnEQ = Zn + (0.601 x Pb) + (0.02687 x Ag).

The COGs used for the Mineral Resource were calculated using on nett smelter return (NSR) values for the individual metals of Pb, Zn and Ag and based on the following:

- at prices of USD 2,057/t, USD 2,759/t and USD 21.24/oz, respectively
- costs based on the F2022 Business Plan
- no mining factors have been applied
- includes planned and unplanned dilution
- no metallurgical factors have been applied; however, metallurgical recoveries were based on metallurgical and smelter performance.

9.10 Estimation/Interpolation Methods

Inverse Distance Weighting to the power of two (IDW^2) methodology was used to estimate Zn, Pb and Ag, using hard boundaries and search ellipsoids with anisotropic weighting that encompasses the geological trends were used to both interpolate and extrapolate the Zn, Pb, and Ag grades. In the historically mined areas, where silver assaying was not routinely undertaken estimates for which no drill data was available were estimated using a regression analysis with Pb, specifically:

Balaria:	Ag = (15.5 x Pb) + 5.6
Baroi:	Ag = (10.4 x Pb) + 4.2
Mochia:	Ag = (7.9 x Pb) + 6.3
Zawarmala:	Ag = (7.2 x Pb) + 10.7.

Restricted local search applied to some of the zones are as follows:

- Balaria: 60 – 100 m on strike, 30 - 75 m on dip, and 10 m across strike, minimum of 6 - 10 and maximum of 24 - 30 samples (dynamic anisotropy), a maximum of 5 composites per drill hole, and three search passes being a factor of 1, 2, 3 or 5
- Baroi: 30 m on strike, 10 m on dip, and 10 - 30 m across strike, minimum of 8 and maximum of 30 samples (dynamic anisotropy), a maximum of 6 composites per drill hole, and three search passes being a factor of 1, 2, and 6
- Mochia: 60 – 100 m on strike, 30 - 75 m on dip, and 10 m across strike, minimum of 6 - 10 and maximum of 24 - 30 samples (dynamic anisotropy), a maximum of 5 composites per drill hole, and three search passes being a factor of 1, 2, 3 or 5
- Zawarmala: 60 – 100 m on strike, 30 - 75 m on dip, and 10 m across strike, minimum of 6 - 10 and maximum of 24 - 30 samples (dynamic anisotropy), a maximum of 5 composites per drill hole, and three search passes being a factor of 1, 2, 3 or 5.

9.11 Classification of Mineral Resources

The level of confidence in the geology and the volume, tonnage and grade estimates determines the classification/s of a Mineral Resource. The lowest level of confidence is an Inferred Mineral Resource and with increasing levels of confidence Indicated followed by a Measured Mineral Resources can be classified. The universal requirement across the three categories is the requirement of reasonable prospects of eventual economic extraction (RPEEE) must exist. There is no uncertainty that all or any part of this Mineral Resource will be converted into Mineral Reserve.

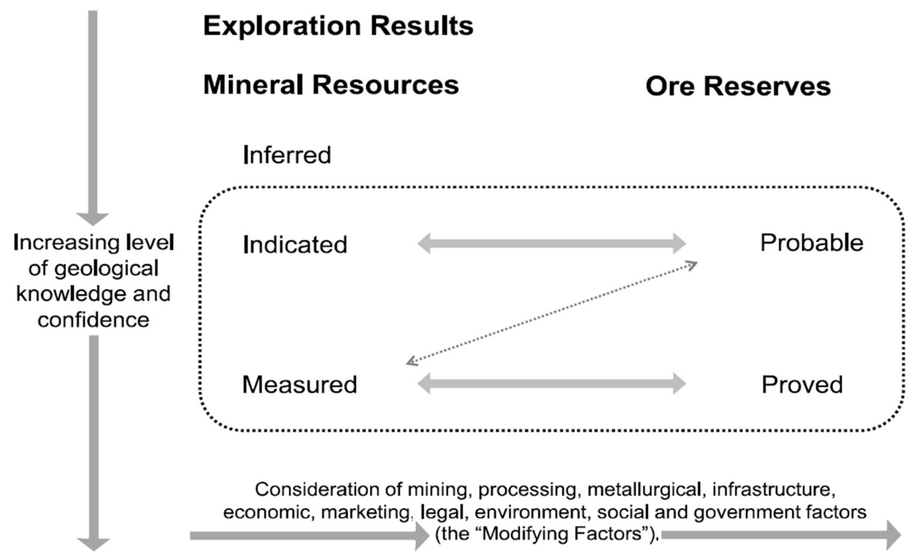


Figure 11: JORC Mineral Resource and Ore Reserve classification framework

Source: The Australasian Code for Reporting Exploration Results, Mineral Resources and Ore Reserves (the JORC Code), p9.

Mineral Resource classification is based on both technical and economic factors, namely:

- geological understanding, continuity and confidence
- grade continuity
- drill hole / sample spatial representativity and spacing
- data quality assurance and control
- appropriate geochemical analytical and density techniques applied
- application of the appropriate estimation methodologies and confidence therein
- RPEEE
- validity and ownership of the relevant government license types such as exploration, and environmental licenses
- consideration of social factors
- legal and governmental risk factors.

Inferred, indicated and Measured classification are based on increasing order of confidence. Various international mineral reporting codes define the criteria required for each confidence category.

An Inferred Mineral Resource is defined as:

- quantity and quality of the grade or quality data is based on 'limited geological evidence and sampling
- geological evidence is sufficient to imply but not verify geological and grade or quality continuity
- has demonstrated RPEEE
- it may not be considered in the assessment of the economic viability of a mining project
- it cannot be converted to Mineral Reserves
- it is expected that most of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with further exploration (Code of Federal Regulations, 229.1300, 2022).

An Indicated Mineral Resource is defined as:

- quantity and quality of the grade or quality data is sufficient to allow the application of modifying factors in sufficient details that will support mine planning and economic viability
- data has been gathered from adequately detailed and reliable exploration, sampling and testing
- geological evidence is sufficient to assume geological and grade or quality continuity between data points
- has demonstrated RPEEE
- can be converted to a probable Mineral Reserve with the application of reliable modifying factors (Code of Federal Regulations, 229.1300, 2022).

A Measured Mineral Resource is defined as:

- the confidence in the quantity and quality of the grade and scientific data is sufficient to allow the application of modifying factors to support detailed mine planning and final determination of the economic viability of the deposit
- data has been gathered from detailed and reliable exploration, sampling and testing data
- geological and grade or quality continuity between data points has been demonstrated
- has demonstrated RPEEE
- can be converted to a Probable and Proven Mineral Reserve with the application of reliable modifying factors (Code of Federal Regulations, 229.1300, 2022).

The Mineral Resources stated for the previous and most current completed fiscal years were based on these factors. The data spacing for the Measured classification required a minimum of 25 x 25 m spacing, a grid spacing of 60 x 60 m for Indicated classification and a spacing of greater than 100 x 100 m for an Inferred classification.

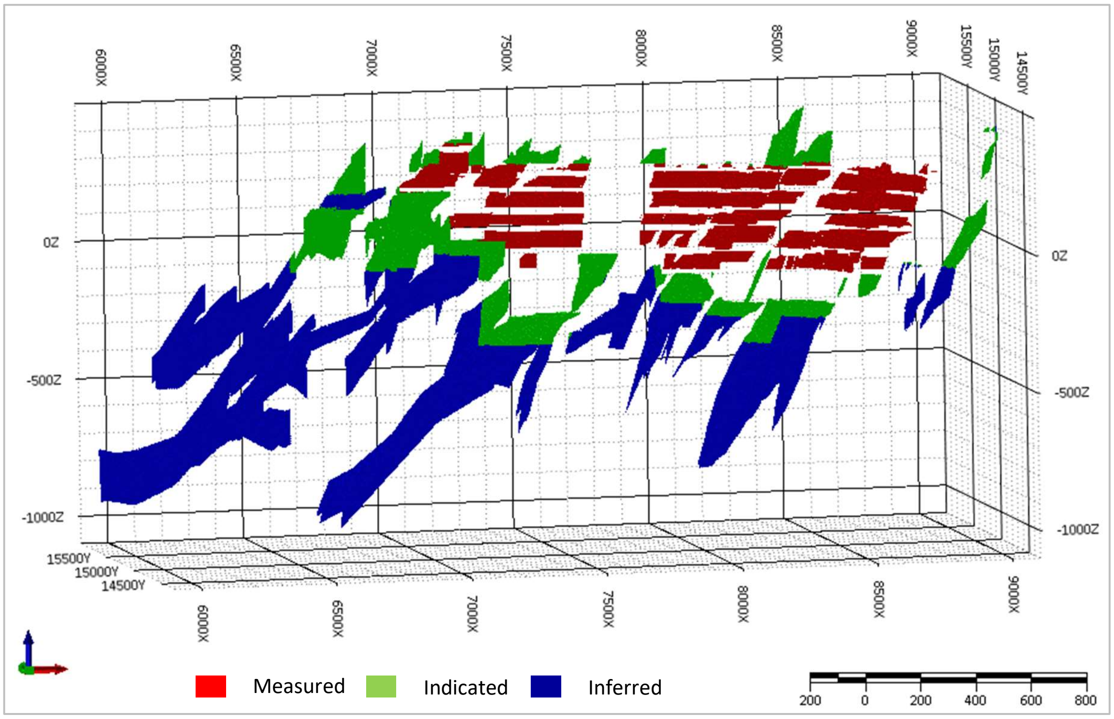


Figure 12: Mineral Resources for Zawar– 31 March 2022

9.12 Grade Model Validation

Grade model validation methods included visually and statistically validating the estimated block grades relative against the original sample results and the generation of swath plots.

Statistically validation indicated that the data population for the grade estimates mirror those of the sample and composited grades. Swath analysis of the block model estimates for the Zn versus the drill hole and composite grades are relatable indicating the estimates honour the input data population.

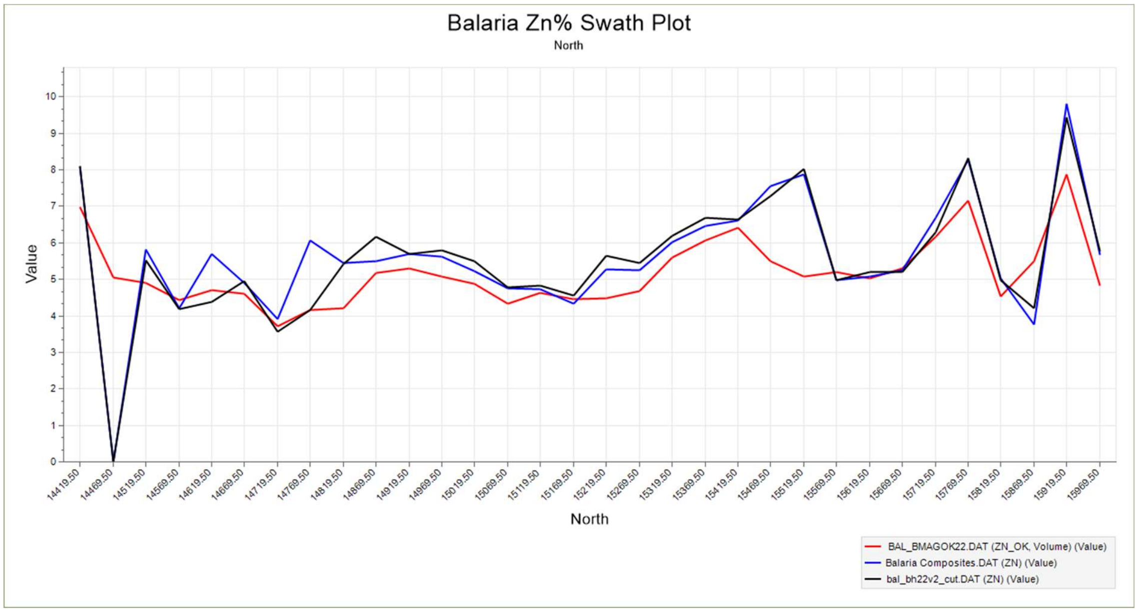


Figure 13: Swath plot (north) for the Balaria block model Zn (%) estimates versus the composite and drill hole grades

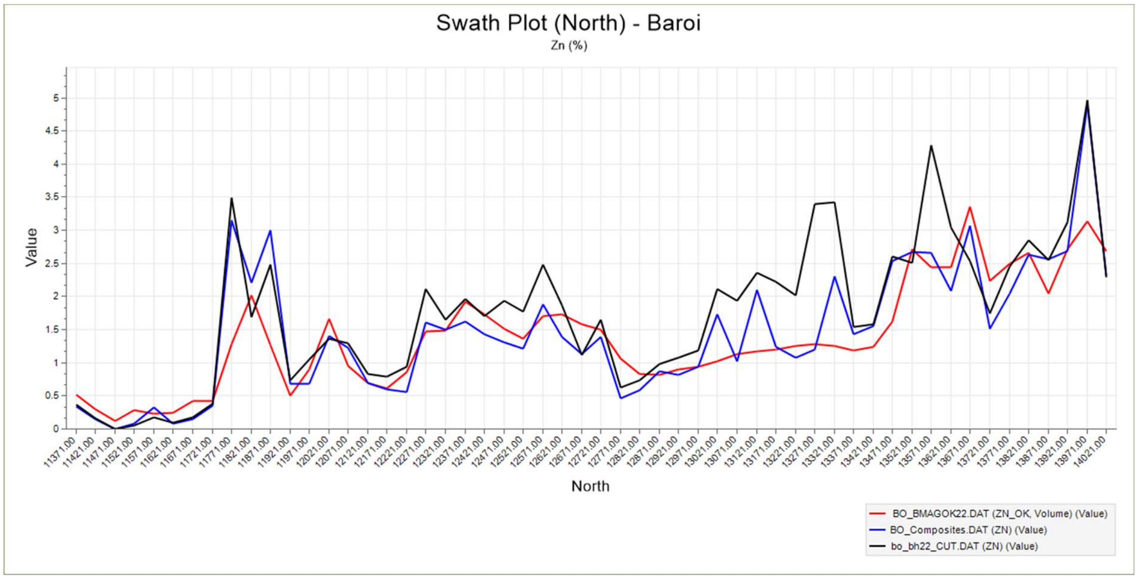


Figure 14: Swath plot (north) for the Baroi block model Zn (%) estimates versus the composite and drill hole grades

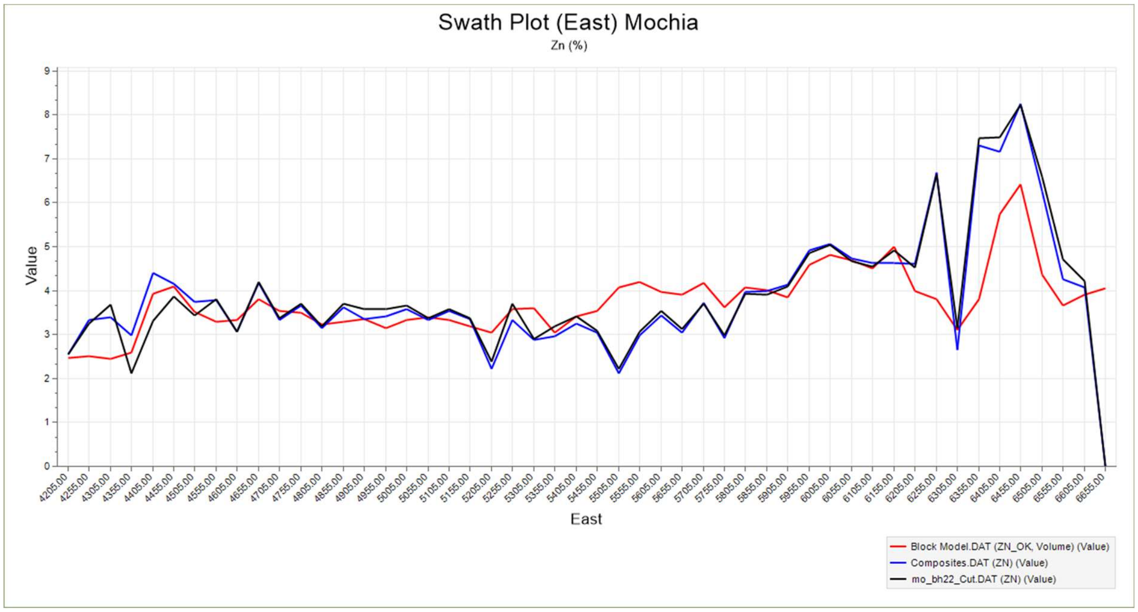


Figure 15: Swath plot (east) for the Mochia block model Zn (%) estimates versus the composite and drill hole grades

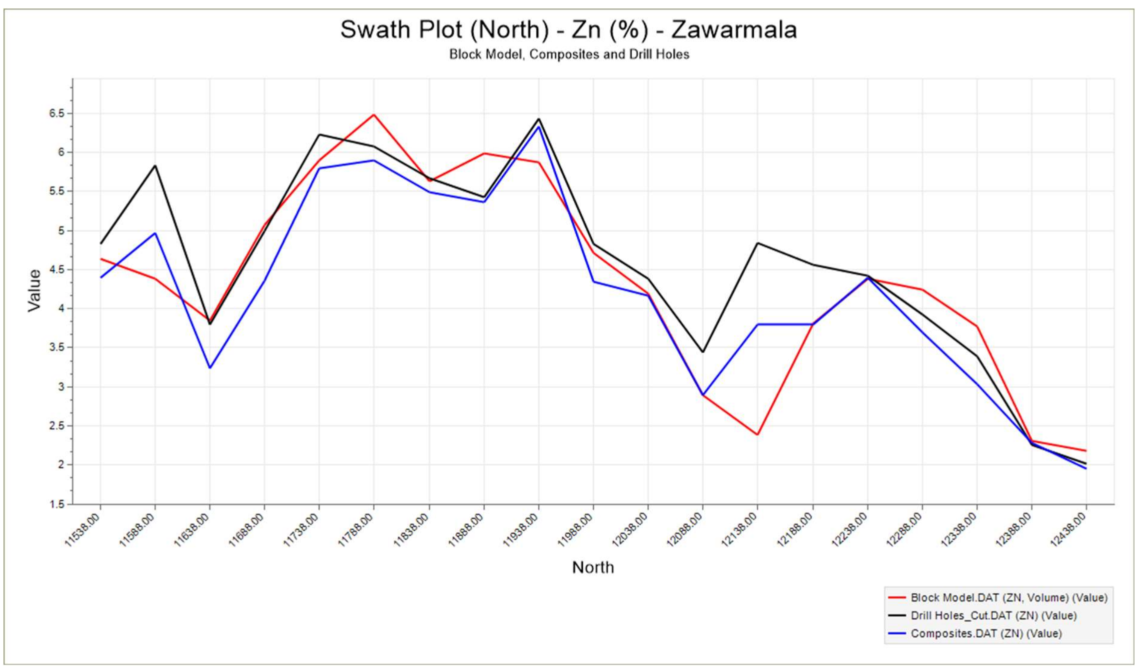


Figure 16: Swath plot (north) for the Zawarmala block model Zn (%) estimates versus the composite and drill hole grades

ABGM considers that sufficient check calculations have been conducted to conclude that the tonnage and grade estimates are considered valid, however there is room for improvement in terms of the estimation scheme and optimisation of the estimation parameters.

9.13 Mineral Resource Statement

The Mineral Resources exclusive of the Mineral Reserves as at the end of the last fiscal year are summarised below and summarises the same period where the Mineral Resources are inclusive of the Mineral Reserves.

The Mineral Resources are reported at a ZnEQ COG of:

- Balaria 3.36%
- Baroi 2.56%
- Mochia 2.67%
- Zawarmala 3.44%.

Table 19: Zawar Mineral Resource Statement (exclusive of Mineral Reserves) – 31 March 2022

Classification	Tonnage	Grade			Metal Content		
	(Mt)	Zn (%)	Pb (%)	Ag (g/t)	Zn (Kt)	Pb (Kt)	Ag (Koz)
Measured	26.4	3.40	2.00	29	909	517	24,549
Indicated	10.3	3.20	2.00	27	327	209	8,984
Measured + Indicated	**36.8**	**3.40**	**2.00**	**28**	**1,236**	**726**	**33,532**
Inferred	79.3	3.60	2.10	34	2,852	1,695	87,051
Total	**116.1**	**3.50**	**2.10**	**32**	**4,088**	**2,421**	**105,583**

- Stated as exclusive of Mineral Reserves
- Stated as underground Mineral Resources
- Measured classification is drilled at a 25 x 25 m spacing, 60 x 60 m for Indicated classification and a spacing of greater than 100 x 100 m for Inferred classification
- The Mineral Resource is limited to a depth from surface of ~1,500 m below surface
- Mineral Resources are reported on a 100% basis
- Totals may not sum due to rounding

The Measured Mineral Resources as a proportion of the total Inclusive Mineral Resource as of 31 March 2022 accounts for ~30% of the tonnes, the Indicated Mineral Resources is ~15%, and the Inferred at ~55%.

Table 20: Mineral Resource Statement (inclusive of Mineral Reserves) – 31 March 2022

Classification	Tonnage	Grade			Metal Content		
	(Mt)	Zn (%)	Pb (%)	Ag (g/t)	Zn (Kt)	Pb (Kt)	Ag (Koz)
Measured	44.6	3.90	1.90	31	1,722	853	45,101
Indicated	21.1	3.80	1.90	32	793	398	21,749
Measured + Indicated	**65.7**	**3.80**	**1.90**	**32**	**2,515**	**1,251**	**66,850**
Inferred	79.3	3.60	2.10	34	2,852	1,695	87,051
Total	**145**	**3.70**	**2.00**	**33**	**5,368**	**2,946**	**153,901**

- Stated as inclusive of Mineral Reserves
- Stated as underground Mineral Resources
- Measured classification is drilled at a 25 x 25 m spacing, 60 x 60 m for Indicated classification and a spacing of greater than 100 x 100 m for Inferred classification
- The Mineral Resource is limited to a depth from surface of ~1,500 m below surface
- Mineral Resources are reported on a 100% basis
- Totals may not sum due to rounding

The net material difference between the Mineral Resource at the end of the 31 March 2022 fiscal year and the preceding fiscal year is demonstrated in table below. The differences relate to depletion or production, changes in commodity prices, additional resources discovered through exploration, and changes due to the methods employed.

Table 21: : Net difference between the 31 March 2022 and 31 March 2021 Minerals Resources exclusive of Mineral Reserves

Classification	Tonnage	Grade			Metal Content		
	(Mt)	Zn (%)	Pb (%)	Ag (g/t)	Zn (Kt)	Pb (Kt)	Ag (Koz)
Measured	3.8	-0.5	-0.1	2	39	53	4,613
Indicated	-3.1	-0.5	0.2	-1	-170	-36	-3,002
Measured + Indicated	**0.9**	**-0.4**	**0**	**0**	**-130**	**17**	**1,611**
Inferred	4.1	-0.6	-0.4	-6	-270	-206	-9,389
Total	**5**	**-0.5**	**-0.2**	**-4**	**-400**	**-189**	**-7,778**

9.14 Relevant Factors that may affect the Mineral Resource Estimates

It is the opinion of the Qualified Person that the likelihood of high-risk factors affecting the Mineral Resource estimates is low.

Risks that can affect Mineral Resource estimates include:

- Geological model
- Spatial representivity of the drill hole data
- Sample QAQC
- Estimation methodology and assumptions
- Estimation search parameters
- Application of grade capping and/or cutting
- Further drill hole results that may impact the grade and tonnage estimates
- Changes to the parameters used to derive the COGs, such as metal prices, operating costs, metallurgical recoveries.

ABGM is of the opinion that these risks have a low probability of having a material impact on the Mineral Resource estimates.

9.15 Qualified Person's Opinion

Conclusions:

- The geology is understood well, and the geological model is sufficiently detailed to estimate reliable Zn, Pb, and Ag grades
- Historical reviews of the data and QAQC and concluded there is sufficient and spatially representative drill holes to estimate reliable grade and tonnage estimates.
- The regression method to determine the missing Ag assay results is appropriate
- At Zawarmala, the use of IDW^2 methodology is appropriate as is the related estimation parameters applied.
- At Baroi, Balaria and Mochia, the use of Ordinary Kriging is appropriate is the related estimation parameters applied.
- Sufficient estimation model validations have been undertaken and indicate the grade estimates are reliable
- The criteria used to define the Mineral Resource confidence categories are appropriate
- The parameters used to determine the COGs are appropriate
- The Mineral Resources are amenable to underground mining
- The estimation of the grades and tonnages have been performed to industry best practices and conform to the requirements of international Mineral Resource reporting codes
- Successful brown-fields exploration to replace Mineral Resources depleted by production has occurred and is on-going
- The nett differences between the most recent Mineral Resources and the previous fiscal year's Mineral Resources are well understood
- The persons undertaking the estimation and classification of the Mineral Resources are sufficiently experienced to undertake such
- The March 31, 2022, Mineral Resource estimate has been estimated in accordance with the December 26, 2018, SEC S-K1300 regulations.

Dr Heather King who reviewed the Mineral Resource estimates and statements is independent of HZL and registered as a professional with the South African Council for Natural Scientific professions (SACNASP) and the Geological Society of South Africa (GSSA).

The Mineral Resource is based on a geological model prepared by the HZL and Zawar technical teams. It has been independently reviewed by the Dr King. Furthermore, the review relies on information provided by HZL, along with technical reports by specialist consultants, and other relevant published and unpublished data, which include relevant geological data and information and reports.

ABGM has endeavoured, by making all reasonable enquiries, to confirm the authenticity and completeness of the technical data upon which the review and Mineral Resource statement has relied. Dr Heather King is suitably qualified and experienced to act as the Qualified Person for the Mineral Resources. Dr Heather King was unable to visit the site.

Recommendations:

- The commodity prices for Zn and Ag be reassessed based on both long-term prices and reliable forecasts
- Alternative geostatistical methodologies be applied in the validation of the estimates
- Interpolation and extrapolation of density estimates to facilitate a higher accuracy in the tonnage and metal content estimates
- Consideration of geological and mining loss factors to facilitate a higher accuracy in the tonnage and metal content estimates.

10 Mineral Reserve Estimate

10.1 Basis, Assumptions, Parameters and Methods

The HZL mine operations and technical teams engage on a universal standard that is applied across all the mine operation from the geology resource estimations to applying the mine designs and evaluating the potential Mineral Reserves. The HZL Resources and Reserves technical team has kept extensive data that is used annually to do the annual mineral reserves statements and calculation. Each mine undergoes individual assessments and apply the modifying factors, grade cut-off calculation and assumptions.

10.1.1 Exchange Rates and Financial Assumptions

The exchange rates applied in the cut-off calculation are based on the LME forecasted indicated in the document below. The following rates were used by HZL:

Dollar to INR Conversion	Long term 5yrs
Dollar value in INR	76.65

Information received from HZL indicate the following parameters were used to calculate the cut-off grade.

Historical prices are stipulated below illustrating the last six years of commodity prices.

Table 22: Historic Commodity Prices

Year	LME Zinc		LME Lead		LBE Silver
(USc/lb)	(USD/t)	(USc/lb)	(USD/t)	(USD/oz)	(USD/oz)
2016	95	2,101	85	1,878	17.1
2017	131	2,892	106	2,327	17.1
2018	131	2,893	102	2,251	15.7
2019	114	2,504	91	2,006	16.2
2020	103	2,278	83	1,836	20.5
2021	120	2,646	88	1,940	23.8

LME Forecast used by HZL for the calculation of the cut-off grades are indicated below. The ten year average of the forecasted prices indicated were used to calculate the cut-off grades.

Table 23: LME Projected Commodity Prices

Particulars	UOM	FY'23	FY'24	FY'25	FY'26	FY'27	FY'28	FY'29	FY'30	FY'31	FY'32	Average
LME - Zinc	$/MT	3,183	2,911	2,684	2,621	2,658	2,706	2,706	2,706	2,706	2,706	2,759
- Lead	$/MT	2,179	2,047	1,974	1,962	1,997	2,082	2,082	2,082	2,082	2,082	2,057
- Silver	$/Troz	22.19	20.47	21.61	21.33	21.30	21.10	21.10	21.10	21.10	21.10	21.24
Ex Rate	Rs/USD	74.94	75.43	76.52	77.73	78.64	79.11	79.51	79.51	79.51	79.51	76.65

The 3 year and 10 year averages is indicated below

Table 24: Next three year average prices

Particulars	UOM	3yr Avg	10yr Avg
LME - Zinc	$/MT	2,926	2,759
- Lead	$/MT	2,067	2,057
- Silver	$/Troz	21.42	21.24
Ex Rate	Rs/USD	75.63	76.65

10.1.2 Cut-off Grade

A zinc and a lead concentrate are produced at ZAW although the principal metal is zinc. Zinc grades at ZAW are good and there is minimal Mineral Resource within the orebody below COG. The COG and NSR assumptions used to support the F2022 Ore Reserve estimate are presented in the tables below:

Table 25: Cut-Off Grades and NSR Calculation inputs

Description	Units	Pb Con	Pb Con	Zn Con
Input Assumptions		**Pb**	**Ag**	**Zn**
Commodity Price	USD/t or USD/oz	2,057	21.24	2,759
Commodity Price	USD/t or USD/g	2,057	0.683	2,759
Exchange rate	USD:INR	76.65	76.65	76.65
Average grade	% Or g/t	2.15	38.79	1.50
Concentrator recovery	%	88.74	73.88	91.90
Concentrate grade	% Or g/t	60.97	915.81	52.60
Moisture content	%			
Payability/ smelter rec	%	96.920	99.444	95.374
Minimum deduction	% Or g/t			
Treatment charge	USD/dmt	297.09		248.19
Refining charge	USD/lb or USD/g		0.02	
Transport cost	USD/dmt			
Freight cost	USD/dmt	5.22		11.94
Mineral royalty	%	19.90	9.36	13.95
NSR Values		**Pb**	**Ag**	**Zn**
Gross payable	USD/dmt	1,216	622	1,384
Treatment charge	USD/dmt	-297.1		-248.2
Refining charge	USD/dmt		-21.8	
Transport cost	USD/dmt			
Freight cost	USD/dmt	-5.2		-11.9
Mineral royalty	USD/dmt	-241.9	-58.2	-193.0
Net payable	**USD/dmt**	**671.4**	**541.9**	**930.9**
Equivalent Grade Calculation				
Metal values	USD/t or USD/g	977.1	0.4	1626.5
Equivalent grade factors	**no**	**0.6**	**0.0**	**1.0**
Equivalent grade	%Zn or %Pb	1.3	1.0	1.5

Total equivalent grade	%Zn or %Pb			**3.8**
NSR	USD/t rom	21.0	17.0	24.4
Total NSR	USD/t rom			**62.4**

10.2 Modifying Factors and Reconciliation

The mine is working to convert all resource and reserve data into electronic format rather than the paper-based polygonal-type planning that has traditionally been used. Some designs are generated using mining software and CMS for surveying of stope voids has been introduced. However, the CMS results are not currently comprehensive and have not been used by HZL to validate performance to the stope design. Modifying factors for planned and external dilution and for mining recovery are traditionally applied to the resource estimates for the various resource blocks identified for mining.

Table 26: Mined versus Processed Grades

Description	Unit	F2017	F2018	F2019	F2020	F2021
		Actual	Actual	Actual	Actual	Actual
Mined	Mt	1.6	1.89	2.57	3.27	3.95
Zn grade	%	2.61	2.38	2.36	2.54	2.6
Pb grade	%	2.12	2.01	1.97	1.97	1.97
Ag grade	g/t	41.3	30.4	32.3	33.6	28.6
Processed	Mt	1.44	2	2.65	3.27	3.95
Zn grade	%	2.71	2.32	2.36	2.54	2.49
Pb grade	%	2.08	2.04	1.96	1.95	1.85
Ag grade	g/t	41.3	31.2	32.4	33.5	29.4
Tonnes factor	%	0.9	1.06	1.03	1	1
Zn grade factor	%	1.04	0.98	1	1	0.96
Pb grade factor	%	0.98	1.02	0.99	0.99	0.94
Ag grade factor	%	1	1.03	1	1	1.03

Table 27: External Dilution and Mine Recoveries applied

Baroi			Mochia		
Type	External Dilution %	Mine Recovery (%)	Type	External Dilution %	Mine Recovery (%)
LS (Longhole Stope)	10	90	LS (Longhole Stope)	10	90
CP (Crown Pillar)	20	85	CP (Crown Pillar)	20	70
Pillar	15	85	Pillar	15	85
Ore Dev	0	100	Ore Dev	0	100
Balaria			**Zawarmala**		
Type	**External Dilution %**	**Mine Recovery (%)**	**Type**	**External Dilution %**	**Mine Recovery (%)**
LS (Longhole Stope)	25	90	LS (Longhole Stope)	5	90
CP (Crown Pillar)	25	70	CP (Crown Pillar)	20	85
Pillar	25	85	Pillar	15	85
CP>-25mRL	20	70	Ore Dev	0	100

10.3 Mineral Reserves

The classification block model reports developed before, was scrutinised and the tonnes were evaluated. This classification model is the start point of the Reserve estimation before external dilution and mine recoveries are applied. The model report suggests there is sufficient tonnes and grade in the model that is used to develop the Reserve Statement in March 2022, to determine the final Mineral Reserves. A direct comparison between the tonnes and grade was conducted as a check. The block model report indicated the tonnes and grade are higher than what is reported in the estimates.

The current Reserve statement reports there is 37.9 Mt at 2.8 g/t Zinc, 1.2% Lead and 23g/t Silver.

Table 28: Mineral Reserves Estimates (2022)

Ore Reserve summary							
Ore Reserve	**Tonnage (Mt)**	**Grade (Zn %)**	**(Pb %)**	**(Ag g/t)**	**Metal (Zn kt)**	**(Pb kt)**	**(Ag koz)**
Proved	23.5	2.8	1.2	23.0	661	286	17,063
Probable	14.4	2.8	1.2	24.0	401	167	11,097
Ore Reserves (Total)	**37.9**	**2.8**	**1.2**	**23.0**	**1,062**	**452**	**28,160**

The Ore Reserve estimate for ZAW has historically been largely derived using manual methods whereby mining blocks are converted to reserves according to the level of completion of the development and resulting information including mapping, sampling and infill drilling. This, together with the characteristics of the orebody and stoping experience leads to individual estimates of the modifying factors in terms of dilution and ore loss. In F2022 the Ore Reserve has been based on computerised mine designs completed according to Mineral Resource block models. The advantage of the recent move to computerised methods is that the mine designs and Ore Reserve Estimate can be extended to include the majority of the Measured and Indicated Mineral Resource rather than being restricted to the areas where all the development has been completed. Reconciliation results indicate that the assumptions for dilution and mining recovery used at ZWM are appropriate.

The ZWM mines have different characteristics in terms of the nature and grade of the orebodies, mining methods as well as access and ore transport systems which leads to different costs and COGs. ZWM has estimated separate COGs for the four mines which vary from 2.2-2.7% ZnEq (fully diluted). Planning needs to focus on the revenue margin in terms of the mined grade at the various deposits and the respective COGs, apart from the higher grade Zawarmala deposit.

The mine has increased production significantly over the last few years producing 5.0 Mt in F2022 compared to historical production of less than 1.0 Mtpa. Current installed plant capacity is 4.7 Mtpa and there are plans for production increases at each of the four mines. Not all the orebodies are suitable for higher volume mining and notably at Balaria there are narrow high-grade veins that would benefit from a more selective approach and smaller mining techniques as well as at Zawarmala where operations are more constrained.

At ZWM, similar to the other operations, development is the critical path to achieving the planned production increases and development constraints are, in places, leading to sub-optimal designs that can affect the quality of mining. CMS is starting to be used more widely and will assist in improvements to stope design and mining quality. There are many initiatives in place at ZWM and the mine is planning to introduce fill methods in an effort to improve mining recovery and quality and recover significant resources of pillars.

Computerised methods have now been introduced and can be used to better evaluate mine performance as well as increase the Ore Reserve Estimate. Baroi and Mochia mines are currently the most advanced in terms of computerised mine design with the design at Mochia linked to an appropriate LoM schedule.

The extensive Mineral Resource at ZWM and notably strike length available for development and mining support the company's long-term aim for production at a level of 5 Mtpa but maintaining good quality of mining in terms of dilution and grade

10.4 Classification and Criteria

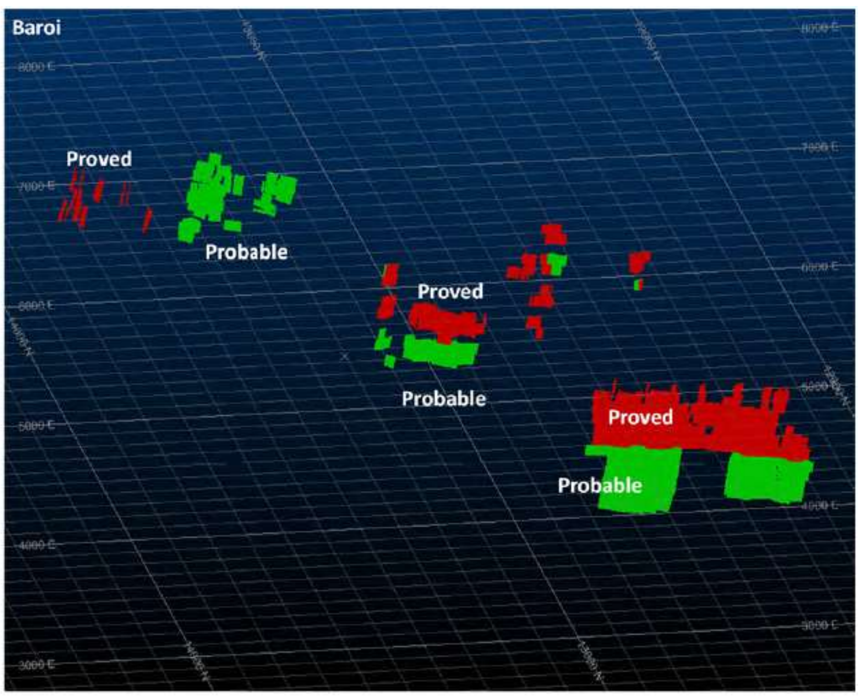


Figure 17: Baroi Ore Reserves Classifications

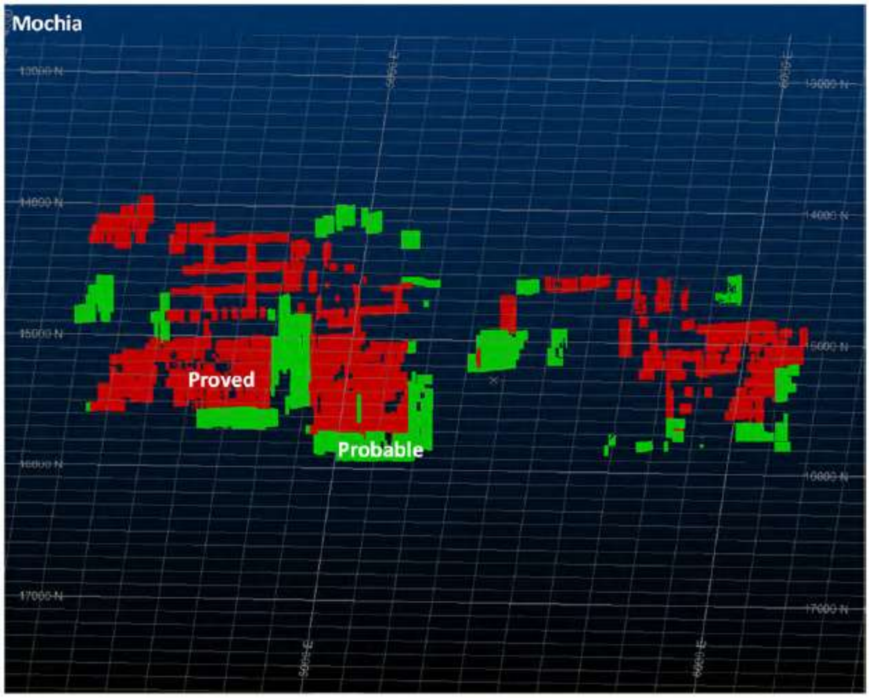


Figure 18: Mochia Ore Reserve Classifications

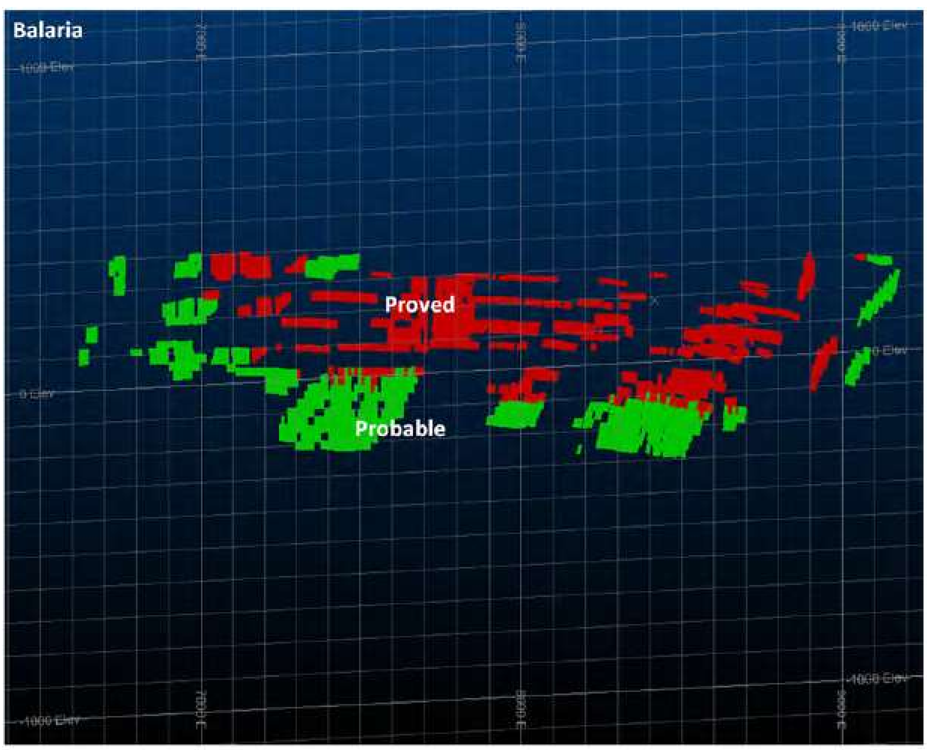


Figure 19: Balaria Ore Reserves Classifications

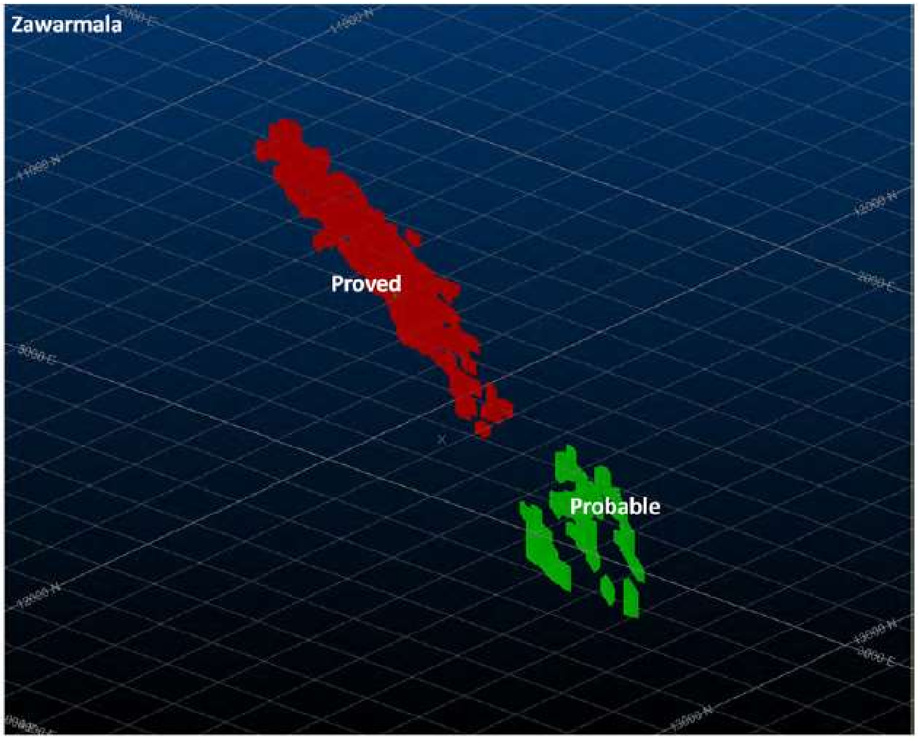


Figure 20: Zawarmala Ore Reserve Classification

10.5 Relevant Factors

Table 29: Input and calculation parameters - Baroi & Zawarmala

No	Description	Units	ZWM ZnEq Baroi (Bara) (Res+Rev)			ZWM ZnEq Zawarmala (Res+Rev)		
			Pb Con Pb	Pb Con Ag	Zn Con Zn	Pb Con Pb	Pb Con Ag	Zn Con Zn
1.00	**Input Assumptions**							
1.01	Commodity Price	USD/t or USD/oz	2,057	21.24	2,759	2,057	21.24	2,759
1.02	Commodity Price	USD/t or USD/g	2,057	0.683	2,759	2,057	0.683	2,759
1.03	Exchange rate	USD:INR	76.65	76.65	76.65	76.65	76.65	76.65
1.04	Average grade	% or g/t	2.15	38.8	1.50	1.10	21.7	2.92
1.05	Concentrator recovery	%	88.7	73.9	91.9	88.7	73.9	91.9
1.06	Regression factor a	no						
1.07	Regression factor b	no						
1.08	Regression factor c	no						
1.09	Concentrate grade	% or g/t	61.0	916	52.6	61.0	949	52.6
1.10	Moisture content	%						
1.11	Payability/ smelter rec	%	96.9	99.4	95.4	96.9	99.4	95.4
1.12	Minimum deduction	% or g/t						
1.13	Treatment charge	USD/dmt	297.1		248.2	297.1		248.2
1.14	Refining charge	USD/lb or USD/g		0.024			0.024	
1.15	Transport cost	USD/dmt						
1.16	Freight cost	USD/dmt	5.2		11.9	5.2		11.9
1.17	Mineral royalty	%	19.9	9.4	13.9	19.9	9.4	13.9
2.00	**NSR Values**							
2.01	Gross payable	USD/dmt	1,216	622	1,384	1,216	644	1,384
2.02	Treatment charge	USD/dmt	-297		-248	-297		-248
2.03	Refining charge	USD/dmt		-22			-23	
2.04	Transport cost	USD/dmt						
2.05	Freight cost	USD/dmt	-5		-12	-5		-12
2.06	Mineral royalty	USD/dmt	-242	-58	-193	-242	-60	-193
2.07	**Net payable**	**USD/dmt**	**671**	**542**	**931**	**671**	**562**	**931**
3.00	**Equivalent Grade Calculation**							
3.01	Metal values	USD/t or USD/g	977	0.44	1,627	977	0.44	1,627
3.02	**Equivalent grade factors**	**no**	**0.601**	**0.02688**	**1.000**	**0.601**	**0.02687**	**1.000**
3.03	Equivalent grade	%Zn or %Pb	1.29	1.04	1.50	0.66	0.58	2.92
3.04	Total equivalent grade	%Zn or %Pb			**3.83**			**4.16**
3.05	NSR	USD/t rom	21.0	17.0	24.4	10.7	9.5	47.5
3.06	Total NSR	USD/t rom			**62.4**			**67.7**
4.00	**Costs and COG Calculation**		**F2022 Act**	**F2022 BP**	**F2023 BP**	**F2022 Act**	**F2022 BP**	**F2023 BP**
4.01	Mining	INR/t rom	1,574		1,456	1,915		1,923
4.02	Processing	INR/t rom	499		631	499		631
4.03	Overhead	INR/t rom	0		0	0		0
4.04	Transport	INR/t rom						
4.05	Sub-total operating cost	INR/t rom	2,073		2,088	2,414		2,554
4.06	Corporate, royalty & others	INR/t rom						
4.07	Other costs	INR/t rom						
4.08	Sustaining capex	INR/t rom	240		156	240		156
4.09	Sub-total other costs	INR/t rom	240		156	240		156
4.10	Total cost	INR/t rom	2,313		2,244	2,654		2,711
4.11	Total cost (USD)	USD/t rom	30.2		29.3	34.6		35.4
4.12	Waste development cost	INR/t rom	1,108		1,339	1,087		659
4.13	Economic cut-off margin	%						
4.14	**Diluted %ZnEq Cut-off Grades**							
4.15	Operating cut-off (diluted)	%ZnEq or %PbEq	1.86		1.80	2.13		2.17
4.16	Section cut-off (diluted)	%ZnEq or %PbEq	2.74		2.87	3.00		2.70
4.17	Economic cut-off (diluted)	%ZnEq or %PbEq	1.86		1.80	2.13		2.17
4.18	**Modifying Factors**							
4.19	Planned dilution	%	23.3		23.3	44.5		44.5
4.20	External dilution	%	12.1		12.1	11.7		11.7
4.21	Mining recovery	%	89.0		89.0	86.7		86.7
4.22	**Insitu %ZnEq Cut-off Grades**							
4.23	Operating cut-off (insitu)	%ZnEq or %PbEq	2.56		2.49	3.44		3.51
4.24	Section cut-off (insitu)	%ZnEq or %PbEq	3.79		3.97	4.84		4.36
4.25	Economic cut-off (insitu)	%ZnEq or %PbEq	2.56		2.49	3.44		3.51
5.00	**Cut-off grade formulas**							
5.01			ZnEq for Zn = 1.000 x %Zn			ZnEq for Zn = 1.000 x %Zn		
5.02			ZnEq for Pb = 0.601 x %Pb			ZnEq for Pb = 0.601 x %Pb		
5.03			ZnEq for Cu = 0.000 x %Cu			ZnEq for Cu = 0.000 x %Cu		
5.04			ZnEq for Ag = 0.02688 x g/t Ag			ZnEq for Ag = 0.02687 x g/t Ag		
5.05			Ore Reserve COG = 1.86 %ZnEq (diluted)			Ore Reserve COG = 2.13 %ZnEq (diluted)		
5.06			Mineral Resource COG = 2.56 %ZnEq (insitu)			Mineral Resource COG = 3.44 %ZnEq (insitu)		

Table 30: Input and calculation parameters - Balaria & Mochia

No	Description	Units	ZWM ZnEq Balaria (Res+Rev)			ZWM ZnEq Mochia (Res+Rev)		
			Pb Con Pb	Pb Con Ag	Zn Con Zn	Pb Con Pb	Pb Con Ag	Zn Con Zn
1.00	**Input Assumptions**							
1.01	Commodity Price	USD/t or USD/oz	2,057	21.24	2,759	2,057	21.24	2,759
1.02	Commodity Price	USD/t or USD/g	2,057	0.683	2,759	2,057	0.683	2,759
1.03	Exchange rate	USD:INR	76.65	76.65	76.65	76.65	76.65	76.65
1.04	Average grade	% or g/t	0.56	18.4	3.73	1.73	21.6	2.48
1.05	Concentrator recovery	%	88.7	73.9	91.9	88.7	73.9	91.9
1.06	Regression factor a	no						
1.07	Regression factor b	no						
1.08	Regression factor c	no						
1.09	Concentrate grade	% or g/t	61.0	949	52.6	61.0	949	52.6
1.10	Moisture content	%						
1.11	Payability/ smelter rec	%	96.9	99.4	95.4	96.9	99.4	95.4
1.12	Minimum deduction	% or g/t						
1.13	Treatment charge	USD/dmt	297.1		248.2	297.1		248.2
1.14	Refining charge	USD/lb or USD/g		0.024			0.024	
1.15	Transport cost	USD/dmt						
1.16	Freight cost	USD/dmt	5.2		11.9	5.2		11.9
1.17	Mineral royalty	%	19.9	9.4	13.9	19.9	9.4	13.9
2.00	**NSR Values**							
2.01	Gross payable	USD/dmt	1,216	644	1,384	1,216	644	1,384
2.02	Treatment charge	USD/dmt	-297		-248	-297		-248
2.03	Refining charge	USD/dmt		-23			-23	
2.04	Transport cost	USD/dmt						
2.05	Freight cost	USD/dmt	-5		-12	-5		-12
2.06	Mineral royalty	USD/dmt	-242	-60	-193	-242	-60	-193
2.07	**Net payable**	**USD/dmt**	**671**	**562**	**931**	**671**	**562**	**931**
3.00	**Equivalent Grade Calculation**							
3.01	Metal values	USD/t or USD/g	977	0.44	1,627	977	0.44	1,627
3.02	**Equivalent grade factors**	**no**	**0.601**	**0.02687**	**1.000**	**0.601**	**0.02687**	**1.000**
3.03	Equivalent grade	%Zn or %Pb	0.34	0.50	3.73	1.04	0.58	2.48
3.04	Total equivalent grade	%Zn or %Pb			**4.56**			**4.10**
3.05	NSR	USD/t rom	5.5	8.1	60.7	16.9	9.4	40.3
3.06	Total NSR	USD/t rom			**74.2**			**66.7**
4.00	**Costs and COG Calculation**		**F2022 Act**	**F2022 BP**	**F2023 BP**	**F2022 Act**	**F2022 BP**	**F2023 BP**
4.01	Mining	INR/t rom	2,036		1,921	1,498		1,629
4.02	Processing	INR/t rom	499		631	499		631
4.03	Overhead	INR/t rom	0		0	0		0
4.04	Transport	INR/t rom						
4.05	Sub-total operating cost	INR/t rom	2,535		2,552	1,997		2,260
4.06	Corporate, royalty & others	INR/t rom						
4.07	Other costs	INR/t rom						
4.08	Sustaining capex	INR/t rom	240		156	240		156
4.09	Sub-total other costs	INR/t rom	240		156	240		156
4.10	Total cost	INR/t rom	2,775		2,708	2,237		2,417
4.11	Total cost (USD)	USD/t rom	36.2		35.3	29.2		31.5
4.12	Waste development cost	INR/t rom	1,207		1,490	1,005		1,235
4.13	Economic cut-off margin	%						
4.14	**Diluted %ZnEq Cut-off Grades**							
4.15	Operating cut-off (diluted)	%ZnEq or %PbEq	2.23		2.17	1.79		1.94
4.16	Section cut-off (diluted)	%ZnEq or %PbEq	3.19		3.37	2.60		2.93
4.17	Economic cut-off (diluted)	%ZnEq or %PbEq	2.23		2.17	1.79		1.94
4.18	**Modifying Factors**							
4.19	Planned dilution	%	21.6		21.6	31.4		31.4
4.20	External dilution	%	24.0		24.0	13.3		13.3
4.21	Mining recovery	%	80.1		80.1	83.8		83.8
4.22	**Insitu %ZnEq Cut-off Grades**							
4.23	Operating cut-off (insitu)	%ZnEq or %PbEq	3.36		3.28	2.67		2.89
4.24	Section cut-off (insitu)	%ZnEq or %PbEq	4.82		5.08	3.87		4.36
4.25	Economic cut-off (insitu)	%ZnEq or %PbEq	3.36		3.28	2.67		2.89
5.00	**Cut-off grade formulas**							
5.01			ZnEq for Zn = 1.000 x %Zn			ZnEq for Zn = 1.000 x %Zn		
5.02			ZnEq for Pb = 0.601 x %Pb			ZnEq for Pb = 0.601 x %Pb		
5.03			ZnEq for Cu = 0.000 x %Cu			ZnEq for Cu = 0.000 x %Cu		
5.04			ZnEq for Ag = 0.02687 x g/t Ag			ZnEq for Ag = 0.02687 x g/t Ag		
5.05			Ore Reserve COG = 2.23 %ZnEq (diluted)			Ore Reserve COG = 1.79 %ZnEq (diluted)		
5.06			Mineral Resource COG = 3.36 %ZnEq (insitu)			Mineral Resource COG = 2.67 %ZnEq (insitu)		

11 Mining methods

11.1 Introduction

Mining methods implemented at the four operations are the same with an underground sub level open stoping mine extraction with backfill. Numerous studies have been conducted by multiple consultancy companies and using the local knowledge of the other Vedanta operations were design, implemented and now operated by the Zawar Group.

11.2 Method and sequence of stoping

At Zawar, the litho-environment is competent and self-supporting and thus favourable for open stopes method of mining. Depending on the ore body configuration, the open stopes are made longitudinal and transverse with respect to ore bodies. Besides conventional stoping, mass blast of remnant pillars has also been successfully executed. It is planned to adopt mining method with backfill at Zawar mines for improving Global stability and for enhancement in ore recovery. The backfill method shall be CRF/ Pastefill/Hydraulic fill and some stopes shall be backfilled through waste rocks based on ore body & grade configuration. It is planned to implement backfilling (hydrofill / pastefill) in wider ore body and CRF in narrow ore body utilizing waste rock available in mine. Some of narrow / secondary stope shall be rock fill also based on technical study.

The option study has been carried out by M/s Golder Associates and it is planned to implement High density hydrofill & CRF at Mochia & Balaria mine, Harvested tailing Pastefill & CRF at Zawarmala & Baroi mine. Based on economic feasibility Hydrofill & CRF plant for Mochia, Paste fill & CRF plant for Zawarmala and CRF plant for Baroi mine is being implemented in Phase-I. The Mochia plant will also serve for backfilling at Balaria mine. The technical study for mining method and stope configuration finalization is under process.

11.3 Sub-level Open Stoping (Longitudinal & Transverse)

11.3.1 Stope & Pillar Design

The rocks of Zawar are competent, but a systemic pillar configuration is designed scientifically with latest numerical modelling techniques using Flac 3D and 3DEC etc at Zawar Mines and also in association with the Scientific Institutes like CIMFR (Dhanbad), NIRM (Kolar) etc. These studies helped in strata stabilization, optimization of extraction ratio and ultimate mineral conservation and maximization of ore extraction by pillar recovery. The stability of the pillars is being monitored by geo-technical instrumentation like Vibrating Wire Stress meter and Multi Point Borehole Extensometers (MPBX). It is also being supplemented by visual inspections and in-house numerical modelling on FLAC 3D. For the ground control purpose, Rock Mass Rating (RMR) and Rock Mass Quality (Q) of the developmental area is determined and based on it, the support to the area is decided in accordance with Systematic Support Rules (SSR) approved by DGMS.

The dimensions of the pillars are decided on the basis of results of the numerical modelling as stated above with main input data consisting of in-situ stress regime, rock mass properties as derived on the basis of Q, rock mass rating (RMR) and the stoping dimensions arrived on empirical basis. The recommendations of the scientific institutions are taken in case of critical areas. The data generated by the instruments installed and the results of the field visits also help in calibrating the model to the current situation. The calibrated model helps in better numerical modelling, thereby minimizing the chances of error.

The rib pillars are generally located in the lean zones from mineral conservation point of view and sometime for global stability vertical pillars extended below in accordance to upper level pillar configuration.

11.3.2 Stope Morphology & Dimensions

Selection of mining methods is mainly dependent on ore body configuration and rock mass condition. The mining method employed at various mines of Zawar mines is Sublevel open stoping and its variant. Ore localization at Mochia, Balaria and Baroi mines permits Longitudinal open stopes but at Zawarmala Transverse Open Stopes are created because of ore localization in fold structure. Besides suitability of the method in litho-environment, it has following additional advantages.

- Persons working in the stope are always on solid ground and under safe roof.
- Access to the stope is either in country rock or in the pillar, which makes the access safer.
- Loading equipment’s are put into the extraction levels only, as the broken ores fall directly to the extraction level.
- Hardly 3-4% broken ore is left in the stoped out areas along the hang wall at trough level.
- Long hole open stoping is more suitable for high degree of mechanization and deployment of higher capacity mining equipment.

Table 31: Typical Stope Dimensions of Longitudinal & Transverse Stopes

Longitudinal Stopes	
Level Interval	– 60-70 m;
Stope Length	– 60-80 m;
Access to Stope	– Shaft, Man & Material Pass or Ramp;
Slot X-cut	– 4 m x 3 m / 5 m x 3.8 m;
Slot Raise	– 2 m x 2 m
Trough Drive	– 3.6 m x 3 m to 4.2 m x 3.8 m
Trough Slope	– 55°
Drill Drive	– Simba – 3.6 m x 3 m; DTH / ITH / EHS – 4 m x 3.8 m
Drill hole Dia.	– Simba – 57mm; DTH / ITH – 115 mm; EHS Drill – 64, 70, 102 mm
Transverse Stopes	
Level Interval	– Sublevels at 25-40 m with one or more extraction levels
Stope Length	– 24 m separated by 14 / 16m Rib Pillars
Excavation & Drill Hole Dimensions – same as Longitudinal Stopes (as above)	

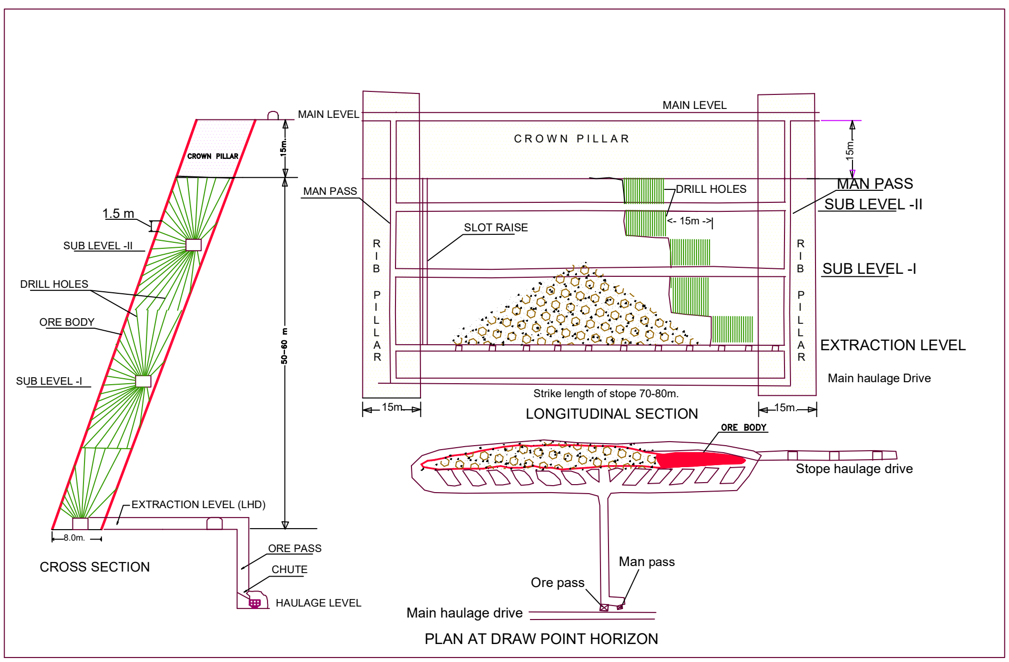


Figure 21: Schematic Outlay of Open Stopes (Longitudinal & Transverse) – SIMBA Holes

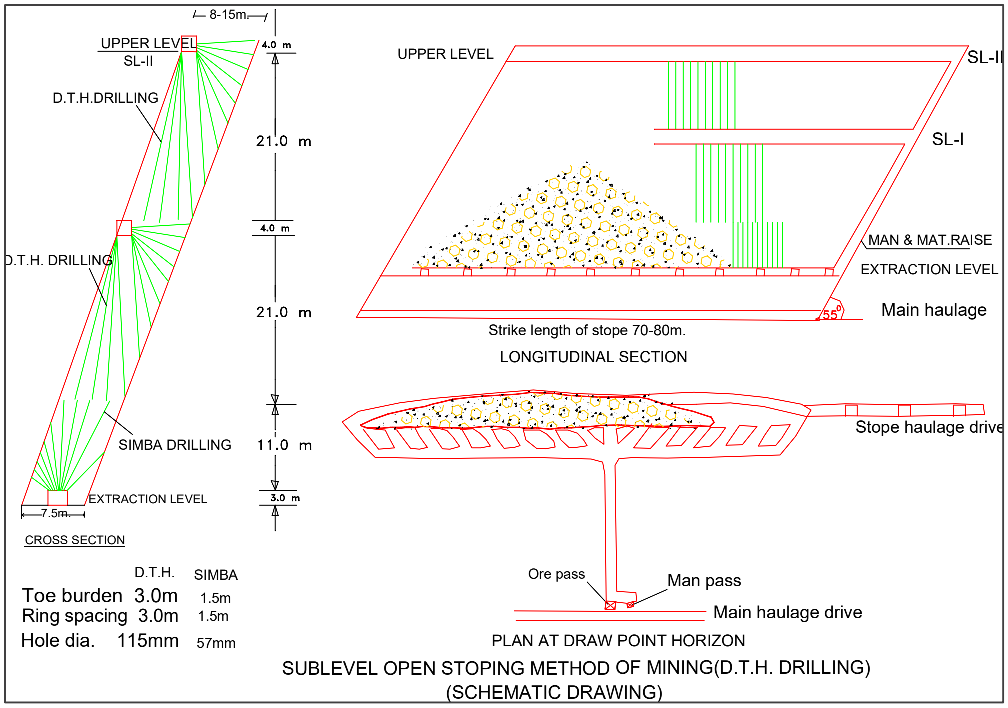


Figure 22: Schematic Outlay of Open Stopes (Longitudinal & Transverse) – SIMBA-DTH / EHS Combinations

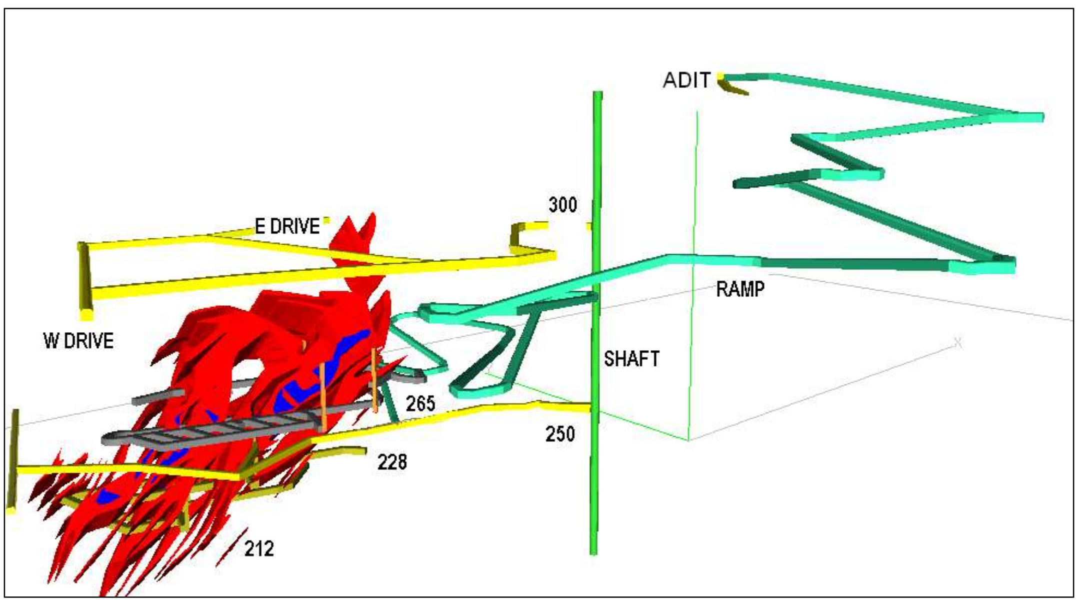


Figure 23: Schematic Outlay of Transverse Stopes

11.3.3 Sub-level Open Stoping (Longitudinal & Transverse)

The litho-environment is competent and self-supporting and thus allows for adoption of open stoping mining method. Longitudinal & Transverse sub-level open stoping method of mining shall be continued with some variants for optimizing mine development quantum, enhancing mechanization, productivity and optimizing ore recovery during Mining Plan and Conceptual Mining period. The various modifications for improvement are as follows:

- Ramp connectivity from Surface at all mines, connecting various levels & sub-levels thus allowing high level of mechanization for development, drilling and ore hauling. The decline from surface allows greater flexibility in operation as it is possible to lower down mining equipment through it. It will enable additional ore hoisting capacity and faster man & material movement to UG location.
- Use of remote control LHD for mucking operation allowing mining of ore being blocked in trough pillars and improving blasted ore recovery into stopes.
- Hauling of ore / waste from underground to surface through 60T / 30T / 20T LPDTs.
- Sublevel stoping with post backfilling:

Mining method with backfilling in selected areas of the mine would be suitable for global stability, enhanced ore recovery and generation of more work areas. But on the other side, Zawar orebodies are of marginal grade and cost of Production plays an important role for economic viability. The increase in production volume, optimum ore recovery and low cost backfilling option can provide us basis for implementing mining method with backfilling.

Numerous backfilling options are available for the Zawar Mine to implement.

11.3.4 Sub-level open stoping (SLOS) with backfilling in primary & secondary sequence.

Are adopted for Mochia, Balaria or Baroi mine subject to technical & economic analysis. A pillar-less SLOS method with backfill with a primary & secondary or continuous retrieve stope sequence can be adopted whereby stopes are mined sequentially on an angled or inverted “V” front for a block height of 100-200 mtr. The ore body shall be divided into separate mining blocks considering various technical parameters i.e. width of ore body, backfilling method, geo-technical modelling, overall global stability of the mine and stoping sequence etc.

Based on an appropriately selected sublevel interval to match the ore-body geometry. Production drilling shall be preferably to down-hole drilling for operational safety and efficiency reasons. The sublevels are accessed from a 1 in 7 gradient decline is located into preferably footwall basement. A crosscut access or ramp access from the decline to the footwall drive provides the access to each level / sublevel. Stope dimensions shall be about 20-60m length & width of ore-body in plan with sublevel intervals of 20-25m. Ore is blasted from the various sublevels (drill-drives) for the full stope height and removed from the extraction level. Typically, the slot may be extracted to ~30% of the stope volume and the remainder then may be blasted on continuous front. Ventilation is primary flow-through from the decline / ramp access along the footwall drive and extremity crosscut to a return air raise system. After completion of ore drawl, backfill barricades shall be installed at each draw point brow and drill drive opening. The primary stopes are filled with cemented fill (paste fill / hydraulic fill / CRF) which is then allowed to cure prior to extracting the adjacent secondary stopes. The suitability of the backfill material is being technically evaluated. Secondary stopes can fill either by mine waste or suitable filling material.

11.3.5 Bench stoping with waste filling

Are applicable in the case of Mochia, Balaria and Baroi mine, where the ore body width is less. This method improves ore recovery, selective mining method and reduces hang wall dilution. It uses development waste as backfill material for mining of adjacent upper level.

In this method, sublevels are accessed from 1 in 7 constant gradient decline located 40-60m into the footwall from the stopes. A crosscut or ramp from the decline to the footwall drive will provide the access to each sublevel. The footwall drive is 20-30m from the stopes and covers the full strike extent of a mine-block. Adjacent contiguous mine blocks along strike are mined without any pillar separation, sharing the ventilation infrastructure at the mine block ends. Load-haul-dump (LHD) remote-operator manhole is required at approximately 20m intervals along each ore drive. Stope dimensions are 25m strike x 20-25m sublevel spacing. Voids are backfilled with Rock fill (RF) or Cemented rock fill (CRF). Next 20-25m upper block is mined standing over filled rock. This method improves ore recovery, selective mining method and reduces dilution. The concept is still under thought process and a decision to implement would require changes in the existing infrastructure of the mines, which in turn is possible after a detailed analysis of viability.

11.3.6 Sub-level open stoping (SLOS) with backfilling in transverse primary & secondary advance sequence

Is applicable for Zawarmala or other mine, where ore body width is more. The ore body can be divided into separate stopes in primary & secondary pattern. Based on an appropriately selected sublevel interval to match the ore-body geometry, the extraction level for the footwall-side stopes is also the drill-drive level for the adjacent hanging wall-side stopes at each sublevel. Production drilling may be either down-hole and/or up-hole drilling with a preference for down-hole drilling for operational safety and efficiency reasons. The sublevels are accessed from a 1 in 7 gradient decline is located into the footwall basement. A crosscut access or ramp access from the decline to the footwall drive provides the access to each sublevel. Stope dimensions shall be about 20-25 m in width, 20-35m in length in plan with 60-80m height having sublevel intervals of 20-25m. Ore is blasted from the various sublevels (drill-drives) for the full stope height and removed from the extraction level. Typically, the slot would be extracted to ~30% of the stope volume and the remainder then may be mass blasted. Ventilation is primary flow-through from the decline / ramp access along the footwall drive and extremity crosscut to a return air raise system. On emptying a stope, concreted backfill barricades shall be installed at each draw point brow and drill drive opening. After mining of primary stopes, it shall be backfilled with paste fill / hydrofill / CRF and after curing & stabilization, the secondary stope shall be extracted, in case of Zawarmala mine, the crown pillar may be left at 100 – 200m interval based on geo-tech study works.

11.4 Mochia Mine

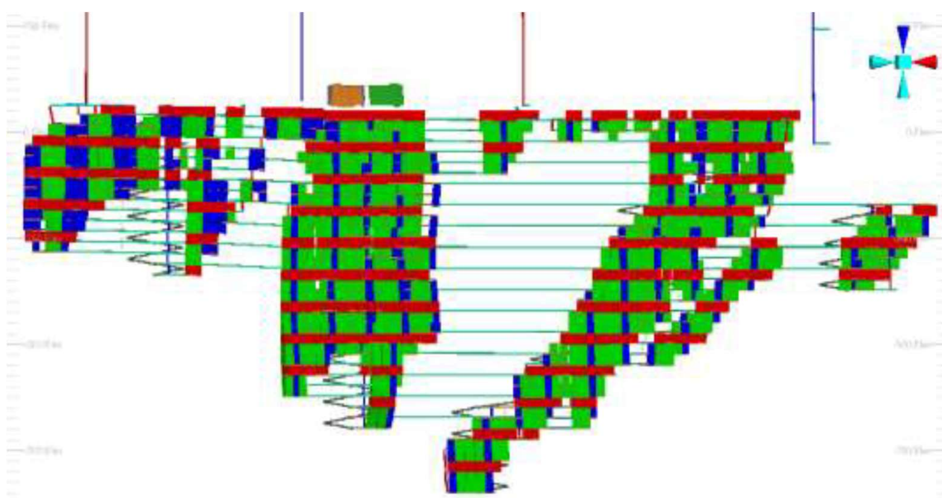


Figure 24: Section View of the Different Areas considered

11.4.1 Mode of entry

Mochia deposit is located in hillocks attaining maximum elevation of 543 mRL with valley levels at 393 & 452 mRL in two sections Central & West Mochia respectively.

Table 32: Mode of entry - Mochia

Area	Type	Purpose	Level Entries
Central Mochia	Shaft [395 to (-)58mRL] Rectangular [5.2m x 3.8m]	Man, material and ore hoisting	Level entries at 307, 240, 173, 106, 39, 3& -29 mRL
West Mochia	Adit at 452mRL & UG shaft [452 to 25mRL] Rectangular [3.25m x 2.9m] Circular [3.8m dia. below 395mRL]	Man & material hoisting	Level entries at 413, 370, 312, 252, 192,132, 57 & 44 mRL
Mochia Portal	Mochia-Balaria Portal [6.5m x 5.5m _407mRL] Decline [5.5m x 5m _407 to 57 mRL]	Man, material and ore hoisting	Level entries at 312, 192, 132, 57, -23 mRL

Besides above Central & West Mochia sections are interconnected at 307/312 mRL, 52/57 mRL & 39/44 mRL. Mochia mine has also interconnectivity with Balaria mine at 6th Level (240/250 mRL) & 9th Level (39/45mRL). In addition to Main Decline, UG ramp access between 312 to 192 mRL at West Mochia has been developed.

The reason behind the selection of the above entries is to help in easy transportation of Man, Material, Ore and Ventilation intake at greater depth. UG Ramp helps in achieving desired productivity of the equipment's, improved ventilation, easy access for man and material to different levels and sublevels. Central Mochia shaft is located in the valley and as such do not pose any threat to environment whereas West Mochia shaft is located underground at 452 mRL with entry via adit (452 mRL). The Highest known flood level (HFL) of Tiri river is 352.72m as on 20.08.1994.

11.4.2 Underground layout

Presently, Central Mochia (CM) and West Mochia (WM) is having underground access through shaft & Decline with following underground extension

Table 33: Extend of Underground - per level

Area	Level (mRL)	Purpose	Dev. Length at level (m)	Departure extent (Easting)
CM	395	Surface & Shaft inset		6173
CM / WM	5thL – 307/312	Connection level	5484	4230 to 6600
CM	6thL – 250	Shaft inset	1200	5470 to 6640
CM	7thL – 173	Extraction level	1453.80	5530 to 6450
CM	8thL– 106	Extraction level	3819.25	5350 to 6310
CM	52	Extraction level	3142	5170 to 6350
CM	-29mRL	Extraction level	886.8	5170 to 6350
CM/WM	9thL – 39/44	Haulage level/Extraction level	3284.20	4400 to 6400
CM	9thA L – 3	Crusher Chamber	110	6160 to 6180
CM	10th L – (-)29	Skip loading station	900	5770 to 6190
WM	452	Adit 5 & Shaft inset	720	4900
WM	413	Shaft inset	653	4350 to 4920
WM	370	Shaft inset	220	4690 to 4960
WM	252	Extraction level	3846.4	4530 to 5120
WM	192	Extraction level	3146.6	4550 to 5270
WM	132	Extraction level	2576.7	4500 to 5240
WM	57	Extraction level	3350.5	4300 to 5300
WM	-23	Extraction level	1378	4200 to 5300
WM	-48	Extraction Level	140	4000 to 5300

As per the prevailing mining method & mining machinery, the average height between two main levels for a stope is 60-75 m, which is further sub-divided into one or two sublevels depending on the blast hole diameter & capability for different drilling machine. A trough level is created at the bottom of the stope for extraction of ore. The lower main level acts extraction level with haulage level. In a typical stope layout, the intermediate sublevels are connected by ramp / raises for access, man & material handling & ventilation. From the lens body, stopes blocks are separated by vertical & horizontal pillars as per requirements of stability.

The Main Decline in West Mochia connected at 312mRL, 192mRL, 132mRL, 57 & -23mRL and started below bottom most level. The Central Mochia & West Mochia connection also completed at 52/57 mRL for decline direct access extension up to Central Mochia workings, which further connects to Balaria mine. Level / Sub-levels are being connected through Ramp for mechanized equipment access and man-material handling. Long ventilation raises being carried out using raise borer.

11.4.3 Method and sequence of stoping

The sequence of stoping involves creation of 80 m wide stopes leaving 20m/25m wide pillars in between two stope panels up to 57mRL. The stopes below 57 mRL is planned to be extracted in primary-secondary sequences. The primary and secondary stopes are proposed to be 60/70 meters in length. Stope will be having sublevel at 25 m interval and general sequence of extraction of each stope is bottom to up. Each sublevel is extracted by up or down blast holes. After the primary stope extraction, they will be backfilled with cemented hydro-fill backfill. The secondary stopes will be extracted after the extraction and back filling of adjacent primary stopes. In sub-level open stoping mining method, slot is opened at the widest portion of orebody and rings are retreated towards the end of the stope. In west Mochia section muck withdrawn at extraction level through LHDs and then directly loaded into mine trucks for hauling through ramps from underground to 406mRL surface. In central Mochia muck withdrawn at extraction level through LHDs and then directly loaded into mine trucks for hauling through ramps from underground to 56mRL COB, ore is fed to the primary crusher, hoisting through skip and dumped into surface bunker / stockpile. It is transported to Mill using surface conveyor.

Mochia mine has four sections namely Central Mochia (6500 -5300 Dep), CWM Series (5300 to 4900 Dep), CW-0 lens (4900 to 4000 Dep) and Narrow lenses in West Mochia (5000 to 4000 Dep). All the four sections have discrete lenses, which are overlapping as well as spread in strike length. Central Mochia lenses mining ongoing at 39 mRL, CW-0 lens at -23 mRL and CWM series lenses at -2 mRL.

11.4.4 System of winding / hoisting

Mochia & Balaria mine have shared ore hoisting system. To achieve the production, the Mochia mine will have two circuits for transportation, crushing & hoisting to stockpile and similarly Balaria mine will also have two circuits for ore hoisting to stockpile.

Table 34: Decline Capacity - Mochia

System		Capacity
Mochia OHS	*Current*	0.54 Mtpa
Mochia Decline	*Current*	+2.0 Mtpa
Balaria Incline	*Current*	*0.8 Mtpa*
Balaria Decline	*Planned*	*+1.0 Mtpa*

Central Mochia ore hoisting system (OHS) has a capacity of 1800 tpd operating common for Mochia & Balaria mine. The Mochia COB connection has been done with ramp, hence Mochia mine became completely trackless mine. Ore hauled through central Mochia ramp is dumped the ore in coarse ore bin (800T capacity) for primary crushing in underground. The primary crusher is situated at the bottom of coarse ore bin (9thA level, 3 mRL). This is “MBE” RBDT Jaw Crusher driven by 220 KW motor having crushing capacity of 200 - 250 tph. From fine ore bin crushed ore is fed to the conveyor by vibratory feeder for its transport to measuring bin of Skip hoisting system. By Skip (Pay load 8.4t) ore is hoisted to surface bunker and fed on BC-2 and BC-3 belt conveyor by reciprocating feeder for ultimate discharge to Mochia stock-pile situated on surface at the beneficiation plant.

West Mochia ore hoisting is being done through Decline using 20T/30T/60T LPDT and has capacity of more than 2.0 Mtpa and primary crushing being done at Surface.

The primary crushed ore is being dumped into Mill stockpile through Belt conveyor system. The mine is having adequate capacity of ore handling system for proposed production.

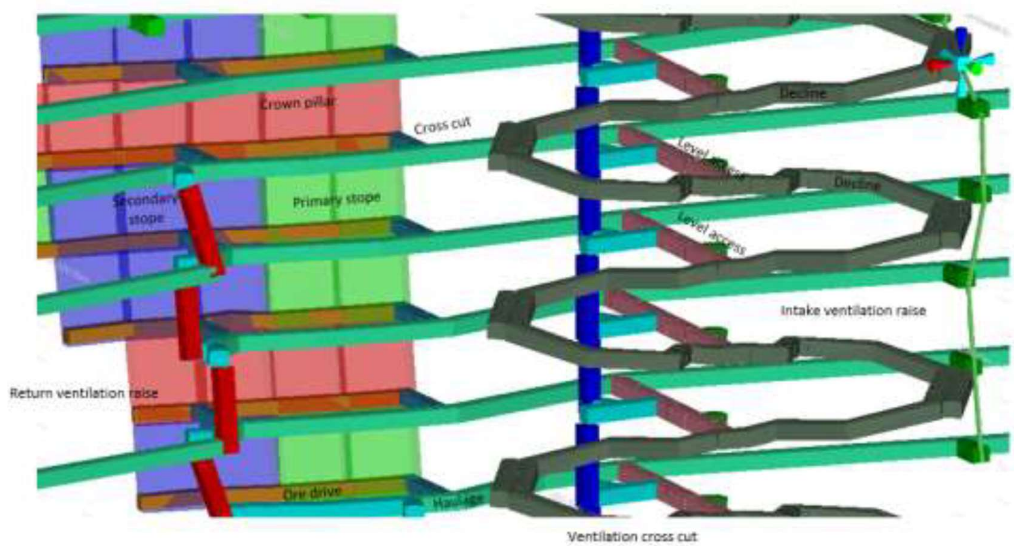


Figure 25: Isometric View of CW0 Development and Stope

11.5 Balaria Mine

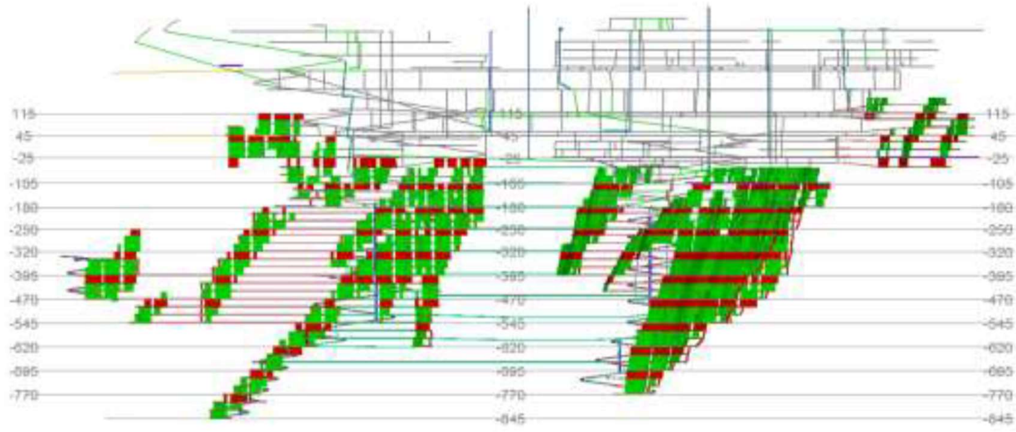


Figure 26: Section view of the different lenses/series considered at Balaria Mine (West & East)

11.5.1 Mode of entry

Balaria deposit is located in hillocks attaining maximum elevation of 543 mRL with valley levels at 378mRL. Thus, the mine entry has been made through adits & shaft

Table 35: Mode of Entry - Balaria

Area	Type	Purpose	Level Entries
Central Balaria	Adit 4 at 378mRL & UG Shaft [378 to (-)50mRL] Circular [3.6m Dia.]	Man & material	Level entries at 314, 250, 190, 120, 105, 45, (-)25 & (-)40 mRL
Western Balaria	Production Incline [387 to 56mRL] 1 in 3.5 Grade Rectangular [3.4m x 2.3m]	Ore hoisting& Second outlet	Level entries at 250, 105 & 45 mRL
Western Balaria	Decline from Surface (407mRL) at 1 in 7 Grade Cross Section [5.5m x 5.0m]	Ore hoisting, Men & material	Decline entry at 407mRL

Ramp is connected from (-)105 to 120 mRL for hoisting lower level ore through Production incline. Balaria mine is also connected with Mochia mine at 45mRL (9th Level) and 250mRL (6th Level). Also, recently Decline is connected from Surface (407 mRL) to -105 mRL.

The reason behind the selection of the above entries is to help in easy transportation of Man, Material and Ventilation intake at greater depth and for Production Incline is to continuous ore handling & Ventilation intake at medium depth. Ramp will help in achieving ore production, desired productivity of the equipment's, improved ventilation, easy transportation of man and material to different levels and sublevels.

The present these primary entries to the deposit cater the following services/ requirements:

- Hauling mined out ore/waste from underground to surface.
- Provides access for men & material to mine.
- Provide intake & exhaust for ventilating air.
- Supply of mine services like power, compressed air, drilling water, drinking water and dewatering supply line etc.

11.5.2 Underground layout

Balaria mine extends from 9000 to 6500 Dep and the mine is intersected by Railway & Tidi river stream. Western side of Railway / River pillar is called West Balaria, and Eastern side is called Central Balaria area. Mine is having underground access through shaft with following underground extension

Table 36: Underground extent of working

	Level (mRL)		m	Departure extent
Balaria	407to (-130)	Decline	4631	8250 to 6650
Balaria	383 to 50	Incline	1593	7700 to 6500
Balaria	415 to 373	Adits	1560	9000 to 6700
Balaria	378	Adit & Exhausted level	1418	9000 to 7970
Balaria	314	Exhausted level	1200	8800 to 7890
Balaria	250	Production Incline (Phase I & Phase II)	2555	8770 to 6500
Balaria	190	Extraction level	2102	8800 to 7000
Balaria	120	Extraction level	1880	8760 to 7320
Balaria	105	Loco Haulage, Production Incline Phase II and Main sump	2280	8750 to 7340
Balaria	45	Haulage / Extraction level	2440	8740 to 6500
Balaria	(-) 25	Extraction level	1439	8740 to 7230
Balaria	(-) 40	LPDT Haulage / Extraction level & Exploratory drive level	1465	8650 to 7420
Balaria	(-) 105	LPDT Haulage / App Ramp/ Extraction level & Exploratory drive level	458	7950 to 8700

As per the prevailing mining method & mining machinery, the average height of a stope is 40-70 m, which is further sub-divided into one or two sublevels depending on the blast hole diameter & capability for different drilling machine. A trough level is created at the bottom of the stope for extraction of ore. The lower main level acts as extraction level with haulage level. In a typical stope layout, the intermediate sublevels are connected by ramp / raises for access, man & material handling & ventilation. From the lens body, stopes blocks are separated by vertical & horizontal pillars as per requirements of stability.

The Main Decline from Surface is completed from portal 407mRL to 120mRL and further developing down to the lower levels. Mochia Main decline has connected to West Mochia 57mRL, which in turn connects to Balaria mine 45mRL through Central Mochia 52mRL.

Level / Sub-levels are being connected through Ramp for mechanized equipment access and man-material handling. Long ventilation raises being carried out using raise borer.

11.5.3 Method and sequence of stoping

The common part of Mining method & Sequence of stoping is dealt in common in section 2B iv). The mining method at Balaria shall be Sublevel open stoping & its variants. Rock Fill (RF), Cemented Rock fill (CRF) and high density hydrofill shall be implemented as backfill variants.

Balaria mine consist of Northern, Eastern, Western, S-Series & N-Series sets of lenses. Northern, Eastern & Western lenses lies in Central Balaria part and mostly exhausted in upper area above (-)25mRL and development & mining activities started below (-)25mRL. S-Series & N-Series lens falls in West Balaria part and were initially explored at 45mRL connection drive between Mochia & Balaria and delineation of block has been initiated between (-)25 to 378mRL surface. Extraction sequence of West Balaria part gradually moving in lateral extent towards western side at all levels and at faster pace to match with the extraction sequence of stopes at Central Balaria part.

Table 37: General Layout of Stopes at Balaria Mine

Particulars	Parameters
Number of Working stopes	3
Size of the panel	60 - 80 (L) x 40 - 60m (H) x 3 –18m (W)
Level Interval	50 - 70m
Thickness of Crown pillar	10 - 25m
Thickness of Sill pillar	10 - 25m
Thickness of Rib pillar	10 - 20m
Size and interval of stope pillar	10 - 25 m crown/sill pillar at 40 - 60 m interval
Size / shape of man way	1.8m(H) x 1.2m(D) x 0.75m(W)
Size / shape of ore pass	2 x 2m – 3 x 3m
Method of stowing / backfilling	At present Backfilling development waste and CRF system will be in operation from FY'21
Method of drainage of stowed stope	NA

Production in 2021-22 to 2024-25 will be carried out from stoping and development operations carried out in blocks between 120-250mRL, 45-120mRL, (-)40-45mRL, 250-378mRL & (-)200-(-)40mRL from various section i.e., Northern lens, Eastern lens, Western lens, S-Series lens & N-Series lens as tabulated below. For this, ramps and raises will be extended to lower & upper levels to attain the proposed production. With further sequential underground exploration, if the orebody continuity is found to extend beyond current limits (vertical & lateral extent) within mine boundary, it will be considered for stoping to maximize ore recovery keeping in point of view with mineral conservation after approval of modification in approved mining plan. As the orebody shows swelling and pinching due to polyphase deformation, the reserves of blocks are subject to change with detailed infill exploration from underground (from different levels). However, the geometry of stopes will be decided after infill drilling and geotechnical modelling.

Figure 27: Section view of the main declines for Balaria Mine

11.5.4 System of winding / hoisting

Mochia & Balaria mine have shared ore hoisting system. To achieve the production during next five years & future enhancement up to its full capacity, the mine has three circuits for transportation, crushing & hoisting to stockpile.

Table 38: Decline Capacity - Balaria

System		Capacity
Mochia OHS	*Current*	0.54 Mtpa
Mochia Decline	*Current*	+2.0 Mtpa
Balaria Incline	*Current*	*0.8 Mtpa*
Balaria Decline	*Planned*	*+1.0 Mtpa*

Broken ore from stope is loaded into LHDs & dumped into LPDT directly / through ore pass for hauling to COB. Ore from (-)40mRL / (-)25mRL/(-)105mRL/(-)200mRL/(-)400mRL is being hauled through UG ramp to 120mRL using 20T LPDT and feed to COB for hoisting.

The production incline is extended from 56 mRL to surface stockpile in Phase-I & Phase II. At 120mRL the ore is dumped in coarse ore bin (1200 t capacity) for primary crushing in underground. The primary crusher is situated at 75mRL (bottom of coarse ore bin). Crushed ore from fine ore bin is fed to conveyor by vibratory feeder for its transport to surface stockpile through production incline.

The 45 mRL haulage level is connected to Mochia mine & ore of stopes between 45–120mRL & below shall be dumped into COB of Mochia mine. It is planned to convert 45mRL to LPDT haulage for dumping through LPDT.

Decline of 5.5 X5 has been developed from Surface to Underground and primary crusher installed at surface for ore crushing. Balaria ore to its full capacity shall be hoisted through Production Incline, Mochia Shaft, Western Balaria decline and Eastern Balaria decline by using 20/30/60 tonne LPDT.

11.6 Zawarmala Mine

11.6.1 Mode of entry

Zawarmala deposit occupies the hillock attaining maximum elevation of 600 mRL. Thus, the mine entry has been made through Adit no. 3 (4m x 3m) at 430 mRL followed by Shaft & Ramp.

Table 39:Mode of Entry - Zawarmala

Area	Type	Purpose	Level Entries
Zawarmala	Adit at 430mRL [4m x 3m] followed by –		
	1) UG shaft [466 to 165mRL] Circular [5.0m Dia.]	Man & material and ore hoisting	Level entries at 433, 355, 300, 250, 225, 200 & 173 mRL
	2) Ramp [430 to (-)55mRL] [4.2m x 3.3m – 1 in 8 / I in 7 gradient]	Man & material and ore hoisting	Level entries at 355, 300, 250, 200, 173, 80, 35, (-)5 & (-)30 mRL and various sub-levels.

The reason behind the selection of the Shaft entry is to help in easy transportation of Man, Material, Ore hoisting and Ventilation intake at medium depth. It is also proposed to connect the Zawarmala mine with bigger size decline at lower depth of -92mRL of Zawarmala Mine to 190mRL of Baroi which will enhance the production capacity of Zawarmala Mine and provide an additional mode of entry to the mine. Ramp will help in desired productivity of the equipment, ventilation intake, easy movement of man, material to different levels & sublevels and transportation of ore to COB and waste to exhausted stope with increasing depth of mine.

11.6.2 Underground layout

Zawarmala mine extends from 2400 to 2900 Dep and Adit as main entry followed by Shaft & Ramp. Shaft (446-165mRL) is connected with different levels i.e., 355mRL – Main Level, 300mRL – Main

Level, 250mRL – COB / Main Level, 225mRL – Crusher chamber, 200mRL – Skip loading station, 173mRL – Shaft Bottom most main level.

Access through ramp presently extends from 430 to (-)134mRL. Besides connectivity at different levels & sublevels, ramp is also connected with shaft at main levels. The ramp is being extended down for future extraction. The underground extent from Ramp is tabulated below:

Mine	Level (mRL)	Purpose	Dev. Length at level (m)	Departure extent (Easting)	Extent (Northing)
CZ	474	Extraction level	6687	2450 to 3350	11400 to 11700
CZ	430	Adit Level, Shaft inset	7223	2400 to 3300	11450 to 12000
CZ	355	Shaft Inset, Extraction level	3950	2600 to 2830	11700 to 11910
CZ	338	Extraction level	1373	2640 to 2860	11720 to 11860
CZ	300	Shaft Inset, Extraction level	2533	2655 to 2810	11750 to 11910
CZ	280	Extraction level	725	2655 to 2810	11780 to 11920
CZ	265	Extraction level	924	2655 to 2810	11950 to 11820
CZ	250	Shaft Inset, LPDT dumping, Expl. Drive	2033	2600 to 2900	11760 to 11930
CZ	228	Extraction level	399	2640 to 2790	11875 to 11930
CZ	225	Extraction level	251	2870 to 2900	11775 to 11850
CZ	210	Extraction level	772	2650 to 2800	11880 to 12000
CZ	200	Shaft Inset	492	2660 to 2900	11775 to 11930
CZ	187	Sub-level	374	2660 to 2810	11965 to 12025
CZ	173	Shaft Inset, Expl. Dr., Extraction level	1129	2600 to 2900	11800 to 12175
CZ	160	Sub-level	174	2650 to 2800	12035 to 12080
CZ	150	Extraction level	545	2630 to 2780	11980 to 12070
CZ	132	Extraction level	352	2680 to 2790	11975 to 12055
CZ	118	Extraction level	299	2675 to 2800	11990 to 12090
CZ	100	Extraction level	700	2675 to 2800	12025 to 12125
CZ	80	Expl. Dr., Extraction level	756	2650 to 2800	12025 to 12125
CZ	35	Extraction level	750	2605 to 2790	12025 to 12185
CZ	(-)5	Extraction level, Expl. Dr.	1242	2550 to 2740	12150 to 12300
CZ	(-)30	Extraction level	811	2550 to 2740	12150 to 12300
CZ	(-) 84	Extraction level	1150	2550 to 2810	12100 to 12320

As the ore body at Zawarmala is typical following axial plane of anticlinorium structure, transverse open stopes with primary and secondary stope configuration are created for mining and then backfilling of the same. Typical transverse stope configuration includes drill drive to drill blast holes by Electro-Hydraulic Simba. Stopes have multiple trough level to cover the extension of ore body in the designed envelope.

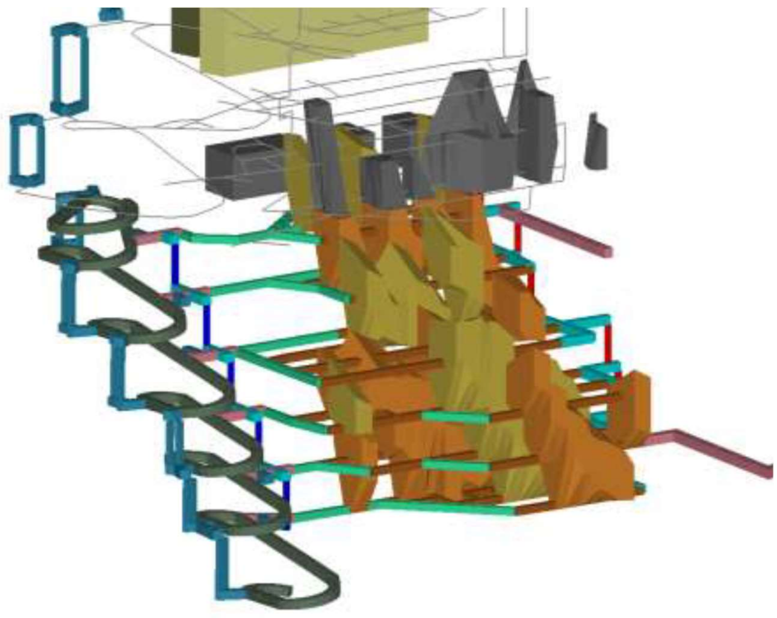


Figure 28: Isometric View of the Transverse Stope Designs (Zawar Mala Mine)

11.6.3 Method and sequence of stoping

The common part of Mining method & Sequence of stoping is dealt in common in section 2Biv). The mining method at Zawarmala mine shall be Sublevel open stoping & its variants.

As the mineralization follows the axial plane of anticlinorium, the sequence of stoping involves creation of 24 m wide stopes leaving 14m/16m wide pillars in between two stope panels up to -30mRL. The stopes below -55 mRL is planned to be extracted in primary-secondary sequences. The primary and secondary stopes are proposed to be 25 meters in width. Stope will be having sublevel at 25 m interval and general sequence of extraction of each stope is top to bottom. Each sublevel is extracted by blast holes drilled in trough fashion from the bottom. After the primary stope extraction, they will be backfilled with cemented paste backfill. The secondary stopes will be extracted after the extraction and back filling of adjacent primary stopes. Starting from S-1, stopes are created with depth. Presently, P-2 stope is under active mining and P-1 & P-0 is under active development. On backfilling of stoped out voids and stabilization of rock mass, pillar extraction shall be started from the left out pillars between 433 to -30mRL.

Detailed numerical modelling study has been carried out by CIMFR, Dhanbad shows that rib and crown pillars can be extracted in tandem with a suitable backfilling system. The neighbouring area is generally not significantly affected by pillar extraction on the count of induced stresses. This is due to the fact that the orebody extent is limited (less than 100m) in all directions due to its confined "pipe" like shape. The rib pillars are to be extracted with both the sides of open stopes backfilled and the rib pillars extracted either in one go or in sub-levels depending on the geometry and ease of mucking. Based on CIMFR recommendation of Pillar extraction, Pillar mining sequence will be followed and R10 is the first pillar which is proposed to be extracted after backfilling and curing of adjacent S-10 Stope (118 -187mRL) and S-11 Stope (80-160mRL). Backfilling plant has been commissioned and paste filling is in progress in S-11 Stope.

In sub-level transverse stoping mining method with post filling, slot is opened at the widest portion of orebody and rings are retreated towards the end of the stope. The muck is then withdrawn at extraction level through LHDs and then directly loaded into mine trucks for hauling through ramps from underground to 250mRL COB. From COB, ore is fed to the primary crusher, hoisting through skip, hauling by diesel locomotive and dumped into surface bunker / stockpile. It is transported to Mill using surface dumpers.

Table 40: General Layout of Stopes at Zawarmala Mine

Particulars	Parameters
Number of Working stopes	1
Size of the panel	80 - 100 (L) x 60 - 80 m (H) x 24-25 (W)
Level Interval	25 - 40m
Thickness of Crown pillar	13 - 25m
Thickness of Sill pillar	13 - 25m
Thickness of Rib pillar	14 - 16m
Size and interval of stope pillar	13 - 25 m crown/sill pillar at 65 - 90 m interval up to -55mRL and below -55mRL at interval of 200m
Size / shape of man way	1.8m(H) x 1.2m(D) x 0.75m(W)
Size / shape of ore pass	2 x 2m – 3 x 3m
Method of stowing / backfilling	Backfilling development waste/ Paste fill/ CRF
Method of drainage of stowed stope	NA

11.6.4 System of winding / hoisting

Zawarmala mine has 0.6 Mtpa Loco haulage and shaft hoisting capacities. The mine has ramp access for trackless mining extending from 430mRL to bottom most level (-)134mRL (gradient 1 in 7 & 1 in 8) and is being utilized for man, material, waste handling & ore transport to COB.

One each Conventional and Koepe winder are installed at Zawarmala mine shaft for ore and man & material hoisting. John Wood makes 560 HP Drum winder having capacity of 100TPH is used for skip (4 MT pay load) hoisting which is used for ore hoisting (0.6 Mtpa capacity) from underground to 446mRL. Venot & Cie make 70 HP koepe winder is used for cage (2MT capacity) hoisting which is used for man & material hoisting from & to the underground. Addition to that baroi- Zawarmala connection decline with bigger size has been planned which will enhance the production capacity of mine up to 0.7Mtpa from FY 2022-23. The mine shall be having adequate capacity of ore handling system for proposed production.

11.7 Baroi Mine

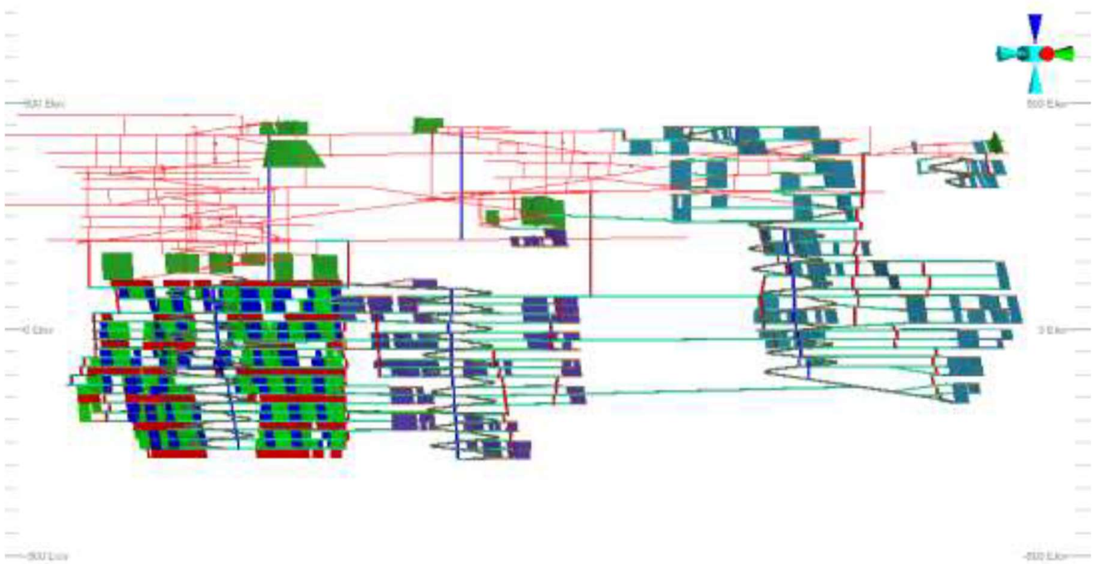


Figure 29: Section view of the main declines and portal positions for Baroi Mine

11.7.1 Mode of entry

Baroi deposit is located in hillocks with mine entry levels at 430 mRL and 422 mRL in two sections Central and North Baroi respectively.

Table 41: Mode of Entry - Baroi

Area	Type	Purpose	Level Entries
Central Baroi	Adit 1 at 430mRL Rectangular [3.6m x 3m]	Man & material	Level entries at 430 mRL
	Central Baroi Ramp [4m x 3m] at 430 mRL	Man & material and ore hoisting	Level entries at 390, 360, 346, 311, 276,190,128& 110 mRL and various sub-level
North Baroi	North Baroi Ramp [4m x 3m] at 422 mRL	Man & material and ore hoisting	Level entries at 390 mRL
	Main Decline [5.5m x 5m] at 423 mRL	Man & material and ore hoisting	Level entries at 390, 302,288, 190 mRL and various sub-level

The reason behind the selection of the above entries is to help in easy transportation of Man, Material, Ore hoisting and Ventilation intake at greater depth. Another subsidiaries ramps are being developed i.e., K Decline, NB Decline and HM Decline for approaching and mining of K-series, North Baroi and Haran Magra ore lenses. Ramp helps in achieving desired productivity of the equipment's and mechanization

11.7.2 Underground layout

Presently, Central Baroi (CB) and North Baroi (NB) is having underground access through adit and ramp with following underground extension

Table 42: Underground extents - per level

Mine	Level (mRL)	Purpose	Dev. Length at level (m)	Departure extent (Easting)
CB	430mRL	Exploratory & Connection drive	1550	4100 to 5150
CB / NB	390/384mRL	Extraction level / Haulage Dr.	1000	4500 to 5150
CB	360mRL	Extraction level	550	4360 to 4500
CB	346mRL	Exploratory Drive	295	4300 to 4400
CB	311mRL	Extraction level	295	4500 to 4745
CB	276mRL	Extraction Level & Expl. Drive	1075	4300 to 4525
CB	190mRL	Extraction Level & Expl. Drive	380	4284 to 4500
CB	110mRL	Extraction Level & Expl. Drive	574	4284 to 4350
NB	390mRL	Exploratory drive & Extraction level	840	5100 to 5632
NB	302mRL	Extraction Level & Expl. Drive	340	4950 to 5122
NB	305mRL	Exploration Level & Expl. Drive	865	5000 to 5200
NB	230mRL	Exploration Level & Expl. Drive	1160	4650 to 5000

Main entry to Central Baroi part of mine is through Central Baroi Ramp (4.2m x 3m) extending from 430 to 190mRL for ore, waste & man & material handling. Central Baroi has entry through Adit no. 1 (3.6 m x 3 m) at 430mRL working as men, material and ore hauling level for stopes above 430mRL.

Main entry to North Baroi part of mine is through Main Decline (5.5 m x 5 m) extending from 422 to 85 mRL towards Central Baroi & 300 mRL towards North Baroi. Another underground ramp (5.5 m x 5 m) started from Main Decline 288 mRL for mining of K-Series stopes reached up to 175mRL. North Baroi section also have North Baroi ramp (4m x 3m from 422 to 387mRL) for entering to North Baroi section to 390mRL and approaching to Haran Magra lense.

Central Baroi & North Baroi sections are interconnected at 430, 390 & 190 mRL through level & ramp connections. Exploratory drives are developed at 430 / 390, 276 / 310/190 & 110 mRL in various parts of the mine.

These main levels are also connected with few more underground ramp & man pass raises, which serve the purpose of men & material movement, ventilation from different levels & sub-levels.

As per the prevailing mining method and mining machinery, the average height for a stope is 60-70 m, which is further sub-divided into two or three sublevels/extraction level depending on the production drilling machine. A trough level is created at the bottom of the stope for extraction of ore. The lower main level acts as haulage level. In a typical stope layout, the intermediate sublevels are connected by ramp / raises on either side for access, man & material handling and ventilation. From the lens body, stopes blocks are separated by vertical & horizontal pillars as per requirements of stability.

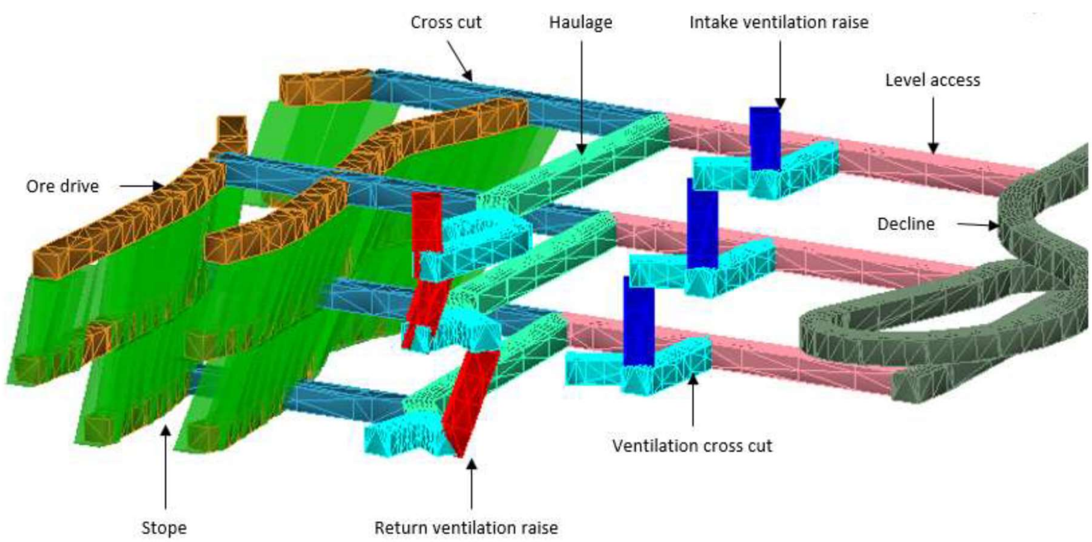


Figure 30: Baroi (Narrow Lens) Stope Designs K-Series and Northern Lens

11.7.3 Method and sequence of stoping

The common part of Mining method & Sequence of stoping is dealt in common in section 2B iv). The mining method shall be Sublevel open stoping & its variants. Cemented Rock fill (CRF) and Rock Fill (RF) shall be implemented as backfill variants.

Baroi mine consist of South Baroi, BK-Series, K-Series, North Baroi & Haran Magra sets of lenses. BK-Series, K-Series & North Baroi lens are in active production at 190, 302 & 390 mRL respectively and shall continue for mining at depth. Haran Magra stope development has been started at 390 mRL and South Baroi exploratory drive development started at 430 & 276 mRL for underground exploration and subsequent mining activity. New area first block is planned for mining above 390mRL leaving safe parting below cap rock in Haran Magra area. South Baroi area planned for surface and UG exploration for bringing it into mining sequence.

Table 43: General Layout of Stopes at Baroi Mine

Particulars	Parameters
Number of Working stopes	4
Size of the panel	60 –80m (L) x 30 - 60 m (H) x 3 –40m (W)
Level Interval	70 - 80m
Thickness of Crown pillar	10 - 25m
Thickness of Sill pillar	10 - 25m
Thickness of Rib pillar	9 - 20m
Size and interval of stope pillar	10 - 25 m crown/sill pillar at 60 - 70 m interval
Size / shape of man way	1.8m(H) x 1.2m(D) x 0.75m(W)
Size / shape of ore pass	2 x 2m – 3 x 3m
Method of stowing / backfilling	Backfilling development waste
Method of drainage of stowed stope	NA

11.7.4 System of winding / hoisting

To achieve the production during 2021-22-2024-25 for future enhancement up to its full capacity, the mine has two circuits for transportation, crushing and hoisting to stockpile.

Table 44: Decline Capacity - Baroi

System		Capacity
Central Baroi Ramp	Current	+0.6 Mtpa
North Baroi – Main Decline	Current	+1.8 Mtpa

Ore from stope is loaded by diesel LHD and dumped directly / through ore pass into LPDT. Central Baroi ramp is being used for transporting ore from underground to Central Baroi surface using 20T LPDT. North Baroi Main Decline is being used for transporting ore from underground to North Baroi surface using 65T/30T/20T LPDT. Decline & Ramps are further getting down at Central Baroi, North Baroi & K-Series section for extracting lower level lenses.

After Primary crushing at North Baroi / Central Baroi surface, the ore is being transported to Beneficiation plant using 20 – 35 MT surface trucks.

Personnel carrier is being used for transporting the manpower to working levels.

11.8 Geotechnical Parameters

The mineralization at Zawar is concentrated along brittle fractures that developed in host dolomite and its variants during various orogenic activities. Dolomite and its variants are characterized as hard and competent rock with high bulk and shear modulus. Rockmass at Zawar mines does not exhibit any large deformations due to its brittle nature. As per in-house and third party numerical modelling, maximum displacement at any part of the surface is not more than 5 mm.

The stoping parameters for each stope are determined by looking into the stability aspects at the local as well as the global level by empirical and numerical tools. Initially, the stope strike/height is determined by empirical methods (Mathew's Stability method in particular). Then the stability of same geometry is checked by numerical modelling with Flac 3D as numerical solver.

The scope of Geo-tech study by M/s Mining One for safe & systematic mining including mineral conservation aspect as follows

- Construct 3D numerical model of historical and planned stoping activities.
- Evaluate the current stability status of the all four mines using available geotechnical information and 3D numerical back-analysis.
- Suggest mine design parameters including stope and pillar dimensions and extraction sequence to maximize ore recovery at depth while maintaining over all ground stability till 1000m depth.
- Suggest alternative measures (e.g., Backfill) to safeguard the current and the future ground stability.

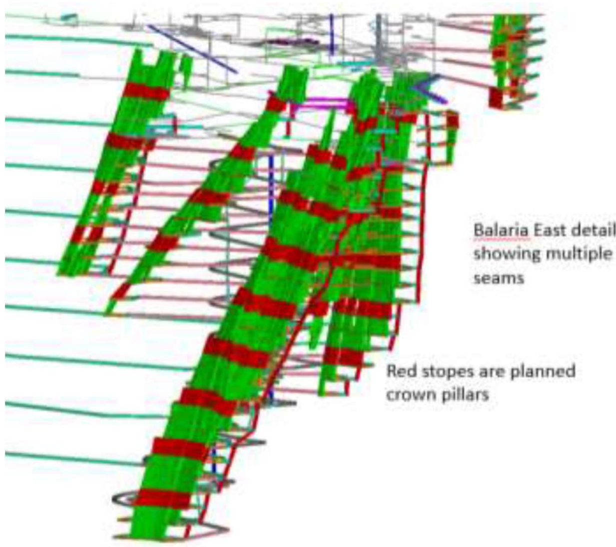


Figure 31: Isometric View of the Multiple Lenses and the Potential Crown Pillars for Extraction.

11.8.1 Support System

To ensure additional safety all the level developments including that in the waste and ore are systematically supported with rock bolts /cable bolts as per Systematic Support Rule (SSR).

Systematic support system in the form of rock bolts, wire mesh is installed in the excavation drives and cross-cuts to ensure long term stability of the strata and roof of development viz., drives and cross-cuts, ramp, incline etc. If poor ground or any geological discontinuity plane is encountered like faults and shear zones etc, some additional support elements are used in the form of Dowels/Steel sets and concreting and/or anything else as per the scenario.

To avoid hanging wall failure leading to in-stope dilution, cable bolts are being installed extending into the hanging wall to arrest excessive wall rock failure, especially in areas where the wall rocks are having low RMR or low angle dipping of ore lenses.

The designed SSR has been validated by CIMFR, Dhanbad to ascertain better stability of the shaft and capital developments through field observations, physical inspection of the area and three dimensional numerical modelling. Also the study is aimed to suggest possible remedial measures to safeguard present and future ground stability. The major recommendation is attached below.

From the empirical and numerical modelling studies the estimated rock bolting parameters for various locations are tabulated below. The pattern of rock bolting and cable bolting for various areas of the mine are shown in the table attached. Cable bolts are suggested only in the Ramp where "fair" rock mass of RMR <60 are encountered, at all the junctions occurring at a ramp section, and at the brow area. Generally, 1.8 m long rock (full column resin) bolts are sufficient for the ground; however, for Ramp of 5.5 m width and for larger size excavations such as passing bays, washing bay, loading point and workshop, 2.4 m full column resin bolts are recommended by CIMFR.

Stope	Size(m)		Empirical		Numerical Modelling						Remark
	W	H	Length of Bolt	Bolt spacing approx.	Rock Load Ht.	Bolt spacing in a row	Row Spacing	No. of Bolts	Support SF	Bolt Density	
Decline	5.5	5	1.77	1.64	1.25	**1.20**	**1.20**	5	2.42	0.69	2 rows side bolting
Ramp	4.2	3.5	1.64	1.45	0.75	**1.20**	**1.20**	4	3.53	0.69	Alt. side bolting
Haulage Drive	4.2	3.5	1.64	1.45	1	**1.20**	**1.20**	4	2.65	0.69	Alt. side bolting
Ore Drive	4.2	3.3	1.64	1.45	0.75	**1.20**	**1.20**	4	3.53	0.69	Alt. side bolting
Cross Cuts	4.2	3.3	1.64	1.45	1.25	**1.20**	**1.20**	4	2.12	0.69	Alt. side bolting
Loading Point	4.2	5.5	1.64	1.45	0.75	**1.20**	**1.20**	4	4.23	0.69	2 rows side bolting
UG Workshp/ Garage	5.5	4.5	1.77	1.64	0.75	**1.20**	**1.20**	5	4.04	0.69	2 rows side bolting
Washing Bay	8	5.5	2.00	2.00	1	**1.10**	**1.20**	8	3.33	0.76	2 rows side bolting; Cables @ 2mX2m
Passing Bay	8.5	5	2.05	2.07	1.25	**1.00**	**1.20**	9	2.82	0.83	2 rows side bolting; Cables @ 2mX2m
Sub Station	4.2	3.5	1.64	1.45	0.75	**1.20**	**1.20**	4	3.53	0.69	1 row side bolting
Conv. Haulage	3.6	3	1.59	1.35	1	**1.00**	**1.20**	4	3.09	0.83	
Conv. Ore Drive	3.6	3.2	1.59	1.35	0.75	**1.00**	**1.20**	4	4.12	0.83	
Conv. Cross Cuts	3.6	3	1.59	1.35	1.25	**1.00**	**1.20**	4	2.47	0.83	
Junctions 4 way	4.2	3.5			1.25	**1.20**	**1.00**			0.83	
Junctions 3 way	4.2	3.5			1.25	**1.20**	**1.00**			0.83	
Y Junction for Decline	5.5	5				**1.00**	**1.00**			1.0	2 rows side bolting; Cables @ 2mX2m
Brow Area	4.2	3.5	1.64		6						Addl. 3 rows of cable bolts (max. 8m length)

Figure 32: Designed support pattern for excavations with different dimensions by NIRM

11.9 Hydrogeological Parameters

11.9.1 Ground Water and Conceptual Model

Ground water occurs under water table (phreatic conditions) in crystalline metamorphics, mostly dolomite and mica schist. Metamorphics are impervious in nature and ground water is held and moves through secondary openings like foliations, fractures, joints etc. Fracture porosity and hydraulic conductivity of metamorphics is very low.

Hill tops are occupied by quartzites and lie above the zone of saturation. Phyllites are the only aquifer having low hydraulic conductivity. The depth of water in buffer zone ranges from 5 to 10 meters below the land surface near the river courses, surface water reservoirs and ponds during post monsoon period while it is deeper in the area from 10 to 20 meters below the land surface. The water levels during post monsoon period are shallow along the Tiri river within the lease area, less than 3 meters below the land surface as there is very limited ground water abstraction by one well located on the bank of Tiri river.

11.9.2 Groundwater Flow Model

Impact of mining on Ground water regime has been studied in all the mines and according to permission to abstract 586 Cu.m/day of ground water has been applied to Central Ground Water authority and is under active consideration.

Depth of workings varies at various parts of mine from minimum 30m to maximum 560m depth. The depth of working at various mines is as follows.

Table 45: Minimum and maximum depth of working

Mine	Depth of Working	
	Minimum	Maximum
Mochia	33m	480m
Balaria	30m	485m
Zawarmala	50m	560m
Baroi	50m	345m

11.9.2.1 Mochia mine

The nature of seepage with respect to quantity of water is as under:

- The main shaft of mines has been provided with a bottom sump where in seepage water from upper levels is collected sliding through walls of the shaft.
- At 5th level (307 mRL), the percolation of water from upper hilly out crop is received through some contact planes and fractures or joints. The seepage takes place along some sections in the form of trickling and slides down along wall of main shaft and collected at the bottom sump of the main shaft.
- The 7th level (173 mRL), there is a sump of 350 Cu.m capacity. The seepage from upper level is collected in this sump and it also receives pumped water from 10thlevel (-29 mRL). There is no significant seepage front in this level. The seepage through joints and contact planes occurs from the compact dolomite having intrusions of Dolerite dykes. The percolated water in this level is diverted through open drainage into the sump from here the water is pumped out of the mines.
- The 8th level is at 106 mRL. At this level, a shear zone of about 10 meters is encountered through which seepage of water takes place in the form of trickling. A section of raise in this level is about 60 meters in height and 2m x 2m in dimension. There is no seepage from this section. From this level to down 9th level, a ramp of 3.6mx3.05m has been constructed with

a slope ratio of 1:9. Along this ramp, there are 3 seepage zones through which water seeps from fracture planes of dolomite rocks and at places it leaves a white shining coating (probably of calcic rich material) on the rocks.

- At 52 mRL no seepage has been observed in the ventilation raise up to 7th level.
- At 9thlevel (39 mRL), a cased bore hole of 75m depth has been drilled through which water from this level drains down to 10th level through gravity. The borehole serves as a conduit and there is no seepage encountered in this borehole.
- Ground water inflow shall be 235 Cu.m/day for proposed Mine Plan period.

11.9.2.2 Pumping arrangement of water from Mochia mine

From 10th level, the collected water is pumped to 7th level sump and from there it is again pumped to overhead tank at the top of the mines. A large volume of water is pumped back into the mines for use in drilling and wetting purposes at different levels. Some volume of this water is supplied to the beneficiation plant.

Further, with the increase in production capacity and working at depth, main sump shall be constructed in West Mochia (-)23 mRL, West Mochia (-)200mRL, Central Mochia (-)200mRL and few temporary sumps shall be constructed at various intermediate levels. The mine water is recirculated back for drilling & development works. Therefore, with increase in development & drilling quantum is proposed to fulfill by increase in recirculation and requirement of additional water from surface. It shall reduce the overall dewatering requirement to surface except for rainy season. Adequate sumps & pumping facilities are planned for proposed capacity.

11.9.2.3 Balaria mine

The nature of seepage with respect to quantity of water is as under:

- In Balaria mines, at 250 mRL at the contact of Dolomite-Phyllite seepage occurs through some of the boreholes drilled for core drilling. In one of such borehole the rate of flow observed was around 200 to 250 ltrs per hour.
- The main seepage zone in Balaria mines is conspicuous within East-West shaft joining in mines. A traverse through this shaft reveals that there is no seepage along raise cuttings or in audits but the section almost beneath the Tiri River course has a seepage zone spread around 30 to 40 meters. This seepage zone is well marked and the nature of seepage is

generally trickling along the ceiling of the shaft, however at a few places seepage finds its passage through sheared or contact zone and flows along the walls of the shaft assuming a shape of miniature spring.

- The major part of the accumulated water re-circulated for drilling and wetting purposes, however, seepage water is also added into it.
- Ground water inflow shall be 135 Cu.m/day for proposed Mine Plan period.

11.9.2.4 Pumping arrangement of water from Balaria mine

From various levels i.e. (-)40 mRL, 45 mRL and 105 mRL, the collected water is pumped to 105mRL main sump. It is again pumped to 250mRL / overhead tank at the top of the mines and recirculation for use in drilling and wetting purposes at different levels. Some volume of this water is supplied to the beneficiation plant also.

Further, with the increase in production capacity and working at depth, main sump shall be constructed in (-)100mRL West Balaria and (-)180mRL at Central Balaria and few temporary sumps shall be constructed at various intermediate levels. The mine water is recirculated back for drilling & development works. Therefore, with increase in development & drilling quantum is proposed to fulfill by increase in recirculation and requirement of additional water from surface. It shall reduce the overall dewatering requirement to surface except for rainy season. Adequate sumps & pumping facilities are planned for proposed capacity

11.9.2.5 Zawarmala Mine

The nature of seepage with respect to quantity of water is as under:

- In Zawarmala mines, a sump is located at the bottom of main shaft at 165 mRL wherein seepage from upper levels and from old workings at the top of the ridge is collected.
- From sump at 165 mRL the water is pumped into another sump at 250 mRL and from this pump it is pumped to an overhead tank at the top of mines.
- There are some seepage zones along the ramp section wherein it occurs in the form of trickling.
- The volume of seepage in this mine is just sustained and seepage water is just sufficient to meet the water requirement of the mines for drilling and wetting purposes.
- Ground water inflow shall be 108 Cu.m/day for proposed Mine Plan period.

A tube well drilled adjacent to the mines near a stream course, supplies drinking water for the workers of the mines. The tube well is drilled up to a depth of 60 meters below ground level. The discharge of tube well is about 3000 liters per hour, and it is pumped for about 5 to 6 hours' daily

11.9.2.6 Pumping arrangement of water at Zawarmala Mine

Pumps are installed at main pumping sump at 250 mRL, which is operated according to the availability of water in the sump. During the monsoon months, when there is more inflow of water in the mine, pump is operated for 12-15 hrs. period and lifting 30 m3/hour to overhead tank for recirculation for drilling and wetting purpose. Zawarmala is dry mine, and no water is discharged outside the mine.

Another sump of 2000cum capacity is planned and development will be done in FY 2021-22 along with the long dewatering holes to directly pump the water up to the surface or 250mRL main sump. Further, with the increase in depth of working, only temporary sumps shall be constructed at various intermediate levels. The mine water is recirculated back for drilling & development works. Adequate sumps & pumping facilities are planned for proposed capacity.

The Zawarmala mine area has one tubewell constructed for providing drinking water for the staff and labours. This tubewell is yielding 3 m3/hour and is operated for 5 to 6 hours a day.

The mine retains water throughout the year. Water is available in the sump during May- June indicates that sump is replenished by ground water. Water derived from direct rainfall in the old working is pumped during the monsoon period.

The bottom of the sump is 165 mRL & 173mRL while the average ground water level is 390 m (10 m bgl), indicating the water level remains through the year above the sump bottom.

11.9.2.7 Baroi Mine

The nature of seepage with respect to quantity of water is as under:

- The Baroi mine has been divided in two parts i.e., above 430 mRL and below 430 mRL. During rainy season inflow of water increases in the levels above 430-mRL mainly through excavations of old workings and this seepage water is collected in the reservoir, which is constructed utilizing old working structures.
- At the entrance through adit in the mine i.e., at 430 mRL about 10 minor seepage locations could be observed in a section of about 200 meters. This seepage zone is across the strike of the formations.

- The seepage water flows down through ramp slope and collects in an abandoned portion of ramp, utilized as a sump at 390 mRL. In this sump the water used for mining (re-circulation) is also collected.
- From this sump the water is pumped out of the mines and collected in an overhead tank. The water is re-circulated into the mines at lower working levels for drilling and wetting purposes.
- The seepage flow along the ramp carries lot of sediments and becomes muddy water and therefore there is a thick accumulation and deposition of silt near the sump and inside it.

The mine gets inflow of ground water is established by the following observations.

- The mine retains water throughout the year. Water is available in the sump during May-June indicates that sump is replenished by ground water. Water derived from direct rainfall in the old working is pumped during the monsoon period.
- The present mRL of bottom of the sump is 240 m (150 m bgl), while the average mRL of water level is 390 m (10 m bgl) indicating the water level remains through the year above the sump bottom
- Further other sumps are available are multiple levels at 276mRL, 190mRL, 337mRL, 305mRL, 288mRL & 248mRL.

11.9.2.8 Pumping arrangement of water at Baroi Mine

There is one pump installed at main pumping sump at 190 mRL which are operated according to the availability of water in the sump. During the monsoon months, when there is more inflow of water in the mine, the pump is operated for longer duration. The pump lifts 30 m3/hour. Baroi is dry mine, and no water is discharged outside the mine.

It is observed from the monthly withdrawal of water from Baroi mine that minimum pumpage is around 3132 m3/month during the non-monsoon months (February) as against 10,044m3/month during the month of August when there is maximum rain fall and water reaches in the old workings.

Further, with the increase in production capacity and working at depth, main sump shall be constructed in Central Baroi 100mRL, North Baroi 230mRL and few temporary sumps shall be constructed at various intermediate levels. The mine water is recirculated back for drilling & development works. Therefore, with increase in development & drilling quantum is proposed to fulfill by increase in recirculation and requirement of additional water from surface. It shall reduce the overall dewatering requirement to surface except for rainy season. Adequate sumps & pumping facilities are planned for proposed capacity.

11.9.2.9 Water from tailing dam:

The decanted water from tailing dam is recycled back to beneficiation plant for reuse. For recycling of water pumping arrangement are in place. The recycled water is directly usable in the beneficiation plant. The quality of the recycled water is within the standards prescribed for industrial effluents. Quality of the water is monitored on monthly basis. Ground water quality is also monitored in upstream &downstream of the tailing dam.

11.10 Mine Design Parameters

Selection of mining methods is mainly dependent on ore body configuration and rock mass condition. The mining method employed at various mines of Zawar mines is Sublevel open stoping and its variant. Ore localization at Mochia, Balaria and Baroi mines permits Longitudinal open stopes but at Zawarmala Transverse Open Stopes are created because of ore localization in fold structure. Besides suitability of the method in litho-environment, it has following additional advantages.

- Persons working in the stope are always on solid ground and under safe roof.
- Access to the stope is either in country rock or in the pillar, which makes the access safer.
- Loading equipment's are put into the extraction levels only, as the broken ores fall directly to the extraction level.
- Hardly 3-4% broken ore is left in the stoped out areas along the hang wall at trough level.
- Long hole open stoping is more suitable for high degree of mechanization and deployment of higher capacity mining equipment.

11.11 Mine Schedule

Table 46: LOM Schedule - Zawar Mines - 2022 – 2031 [supplied by HZL]

Reserves	FY21	FY22	Reserves	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Mochia	10.37	10.4	10,369,011	1,600,000	1,800,000	2,200,000	2,200,000	2,200,000	369,000			
Balaria	12.19	16.5	16,468,531	1,050,000	1,500,000	1,918,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Baroi	5.92	7.7	7,724,049	1,750,000	2,000,000	2,000,000	1,974,000					
Zawarmala	3.01	3.3	3,338,075	600,000	750,000	750,000	750,000	488,000				
ZAWAR-Total	**31.49**	**37.9**		**5,000,000**	**6,050,000**	**6,868,000**	**6,924,000**	**4,688,000**	**2,369,000**	**2,000,000**	**2,000,000**	**2,000,000**
Sus Dev Requirement (m)												
Mochia				6,700	7,500	9,200	9,200	9,200	1,500	-	-	-
Balaria				5,300	7,500	9,600	10,000	10,000	10,000	10,000	10,000	10,000
Baroi				9,900	11,300	11,300	11,200	-	-	-	-	-
Zawarmala				1,800	2,300	2,300	2,300	1,500	-	-	-	-
ZAWAR-Total				**23,700**	**28,600**	**32,400**	**32,700**	**20,700**	**11,500**	**10,000**	**10,000**	**10,000**
Sus Dev Requirement (cum)												
Mochia				147,400	165,000	202,400	202,400	202,400	33,000	-	-	-
Balaria				116,600	165,000	211,200	220,000	220,000	220,000	220,000	220,000	220,000
Baroi				198,000	226,000	226,000	224,000	-	-	-	-	-
Zawarmala				36,000	46,000	46,000	46,000	30,000	-	-	-	-
ZAWAR-Total				**498,000**	**602,000**	**685,600**	**692,400**	**452,400**	**253,000**	**220,000**	**220,000**	**220,000**

11.12 Mining Fleet Requirements

11.12.1.1 Mochia Mine

Mine Development started carrying using Drill Jumbo, LHD & LPDT combination. Maximum of the waste being dumped into exhausted stopes using LHD / LHD-LPDT combination. Electro-Hydraulic machines started being used in place of Compress air operated m/c for faster exploratory and production drilling. Muck handling capacity enhancement planned with use of larger capacity loading and hauling equipment. In the same line 60T LPDT & 17T/20T LHD started being used in CW(0), CWM lenses at Mochia mine. Other utility vehicles i.e., High speed exploratory drilling machines, Personnel Carrier, RBO, Scissor Lifter, Grader, water sprinkler etc. are being also deployed for facilitating the mechanized work.

Adequate ore hoisting system planned for hoisting through Central Mochia Shaft & Decline combination. For enhancement of mine production, additional major mining equipment proposed to be added. The status of existing and proposed mine equipment is illustrated in Table below:

Table 47: List of Equipment Existing & Proposed:

Equipment	Numbers			Size /Capacity	Make	Motive Power	HP / KW
	Existing	Proposed	Total				
LPDT 60T	6	4	10	60T	CAT	Diesel	560KW
LPDT 30T	4		4	30T	Atlas Copco	Diesel	240KW
LPDT 20T	4		4	20T	GHH / Atlas Copco	Diesel	194KW
LHD 20/21 tonne	3	1	4	17T	CAT	Diesel	305KW
LHD 17 tonne	1		1	17T	CAT	Diesel	305KW
LHD 10 tonne	2	6	8	10T	GHH / Atlas Copco	Diesel	200KW
LHD 6-7 tonne	8	(-6)	2	7T	GHH / Atlas Copco / CAT	Diesel	129KW
Drill Jumbo	11	3	14	45mm	Atlas Copco / GHH / Sandvik	Electric	87KW
Electrohydraulic Drill	4	2	6	64/70/102mm	GHH / Resemin	Electric	58KW
Grader	1		1		GHH	Diesel	186KW
Personnel Carrier	4		4	32 Persons	GHH / Normet	Diesel	67KW
Scissor Lifter	5		5		GHH / Normet	Diesel	67KW
Charmec	1	2	3		Normet	Diesel	67KW
Diesel Bowser	1		1		GHH	Diesel	67KW
Scaler	1		1		Normet	Diesel	67KW
Water Sprinkler	1		1		Normet	Diesel	67KW
Mine Light vehicles (RBO)	2	1	3	5 Seater	Normet / GHH	Diesel	44KW
Explosive Carrier		1	1	3-4t	GHH	Diesel	67KW
Mine pumps	6	4	10	30 - 400 Head		Electric	5- 175 HP
Compressor	5		5	2500/1000 /500 CFM	Crepple/IR/ Atlas copco	Electric	510/ 250/ 120 HP
Ventilation fan	3	3	6	30/60/150 m^3/sec	Zetron/Hydon	Electric	160/500 kW

Table 48: Productivity of Mining Equipment – Mochia Mine

Equipment	Availability	Utilization	Run Hrs	Productivity		Equipment Nos.	Equipment Potential		
	Plan	Plan	Plan	UoM	Plan		UoM	Potential	Proposal
LPDT - 60T	83%	70%	5,020	TKPH	140	10	Mt	2.91	2.86
LPDT - 30T	83%	70%	5,020	TKPH	60	4			
LPDT - 20T	83%	70%	5,020	TKPH	45	4			
LHD - 17T	83%	67%	4,800	TPH	80	5	Mt	3.70	3.43
LHD - 10T	83%	67%	4,800	TPH	40	8			
LHD - 7T	83%	67%	4,800	TPH	25	2			
Drill Jumbo	75%	25%	1,620	mph	55	14	Km	15	14.8
Prod. Drill	75%	35%	2,268	mph	35	6	Km	476	440

11.12.1.2 Balaria Mine

Mine Development started carrying using Drill Jumbo, LHD & LPDT combination. Currently all the waste being dumped into exhausted stopes using LHD / LHD-LPDT combination. Electro-Hydraulic machines started being used in place of Compress air operated m/c for faster exploratory and production drilling. Muck handling capacity enhancement planned with use of larger capacity loading and hauling equipment. Other utility vehicles i.e., Personnel Carrier, RBO, Scissor Lifter etc. are being deployed for facilitating the mechanized work.

Adequate ore hoisting system planned for hoisting through Production Incline, Mochia Shaft and Decline combination. For enhancement of mine production, additional major mining equipment proposed to be added. The status of existing and proposed mine equipment is illustrated in Table below:

Table 49: List of Equipment's Existing & Proposed

Equipment	Numbers			Size /Capacity	Make	Motive Power	HP / KW
	Exist	Propose	Tot.				
LPDT 60T		5	5	60T	CAT	Diesel	560KW
LPDT 30T				30T	Atlas Copco	Diesel	240KW
LPDT 20T	13	(-2)	11	20T	Sandvik	Diesel	240KW
LHD 20/21 tonne		3	3	17T	CAT	Diesel	305KW
LHD 17 tonne				17T	CAT	Diesel	305KW
LHD 10 tonne	2	3	5	10T	Atlas Copco	Diesel	186KW
LHD 6-7 tonne	9	(-4)	5	7T	CAT, Atlas Copco	Diesel	150KW
Drill Jumbo	10	2	12	38/45mm	Atlas Copco	Electric	58KW
Electrohydraulic Drill	4	1	5	64/70/102mm	Atlas Copco / Resemin	Electric	58KW
Grader		1	1		Normet	Diesel	186KW
Personnel Carrier	2	1	3	32 Persons	Normet	Diesel	65KW
Scissor Lifter	3		3		Normet	Diesel	67KW
Charmec		2	2		Normet	Diesel	67KW
Diesel Bowser	1		1		Normet	Diesel	67KW
Scaler	1		1		Normet	Diesel	67KW
Mine Light vehicles (RBO)	2	1	3	8	Normet	Diesel	44KW
Explosive Carrier	1		1	3-4t	Normet	Diesel	75KW
Mine pumps	12	3	15	100 - 450 Head		Electric	12.5-168 HP
Compressor	4		4	30-70 m3/min &1250LPM,500 CFM	Crepple/CPT/KGK/ELGI Atlas copco	Electric	10/100 / 250/510 /6030 HP
Ventilation fan	3	1	4	135/150 m3/sec	Andrew Yule/Hydon	Electric	160/500 kW

Table 50: Productivity of Mining Equipment's – Balaria Mine

Equipment	Avail	Util	Run Hrs	Productivity		Eq. Nos.	Equipment Potential		
	Plan	Plan	Plan	UoM	Plan		UoM	Potential	Proposal
LPDT 60t	83%	70%	5020	TKPH	120	5	Mt	2.1	1.95
LPDT 30t	83%	70%	5020	TKPH	67	0			
LPDT 20t	83%	70%	5020	TKPH	46	11			
LHD - 17t	83%	67%	4800	TKPH	80	3	Mt	2.78	2.54
LHD - 10t	83%	67%	4800	TKPH	40	5			
LHD - 7t	83%	67%	4800	TKPH	28	5			
Drill Jumbo	75%	25%	1620	TKPH	55	12	Km	13	12
Prod. Drill	75%	35%	2268	TKPH	35	5	Km	397	375

11.12.1.3 Zawarmala Mine

Mine Development is being done using Drill Jumbo, LHD & LPDT combination. All the waste being dumped into exhausted stopes using LHD & 20T/42T/60T LPDT. Production drilling is being done by Electo-Hydraulic machines. High speed Dynatech exploratory drill rigs are introduced for faster exploratory drilling. Other utility vehicles i.e., Personnel Carrier, Scissor Lifter and Grader being used, and light vehicle planned to deploy for facilitating the mechanized work.

Adequate ore hoisting system is available for hoisting through Shaft and Haulage system. The status of existing and proposed mining equipment is illustrated in Table below:

Table 51: List of Equipment's Existing & Proposed

Equipment	Numbers			Size /Capacity	Make	Motive Power	HP / KW
	Existing	Proposed	Total				
LPDT 20/30t	8	-	8	20T	GHH	Diesel	194 KW
LHD 6/7t	4	0	4	6/7T	GHH	Diesel	129 KW
LPDT 42/60T	0	2	2	42/60T	GHH	Diesel	460KW
LHD 10/14T	1	2	3	10/14T	GHH	Diesel	285KW
Drill Jumbo	2	1s	3	45mm	Atlas Copco	Electric	45 KW
Electrohydraulic Drill	1	1	2	64/70/102mm	GHH	Electric	70 KW
Explosive Carrier	-	2	2	3-4T	GHH / Normet	Diesel	100 HP
Personal carrier	2	-	2	26-Seater	GHH	Diesel	67 HP
Road grader	-	1	1		Normet	Diesel	75 KW
Scissor Lifter	1	1	2		Normet	Diesel	67 KW
Mine Light vehicles (RBO)	1	1	2	8-Seater	GHH / Normet	Diesel	170 HP
Mine pumps	2	2	4	200m Head		Electric	
Compressor	3	-	3	1000 cfm		Electric	
Ventilation fan	2	-	2	150cum/Sec & 70cum/sec	Howden	Electric	500 KW
Exploratory Drilling Rig UCD 40	1	-	1	400m	DynaTech	Electric	45 KW
Exploratory Drilling Rig UCD 60	1	-	1	600m	DynaTech	Electric	90 KW

11.12.1.1 Baroi Mine

Mine Development is being done using Drill Jumbo, LHD & LPDT combination. Majority of development waste being dumped into exhausted stopes and partly brought to surface and being used for tailing dam height raising. Electo-Hydraulic machines started being used in place of Compress air operated m/c for faster exploratory and production drilling. Muck handling capacity enhancement planned with use of larger capacity loading and hauling equipment. In the same line 60T LPDT & 17T LHD started being used in North Baroi & Central Baroi. Other utility vehicles i.e., Personnel Carrier, Scissor Lifter, RBO and Grader being used for facilitating the mechanized work.

Adequate ore hoisting system planned for hoisting through Decline & various UG ramp. For enhancement of mine production, additional major mining equipment proposed to be added. The status of existing and proposed mine equipment is illustrated in Table below:

11.12.2 Equipment Productivity and Usage

Table 52:Mine Fleet compliment

Equipment	Avail	Util	Run Hrs	Productivity		Eq. Nos.	Equipment Potential		
	Plan	Plan	Plan	UoM	Plan		UoM	Potential	Proposal
LPDT 60t	83%	70%	5020	TKPH	110	7	Mt	2.76	2.73
LPDT 30t	83%	70%	5020	TKPH	57	2			
LPDT 20t	83%	70%	5020	TKPH	51	8			
LHD - 17t	83%	67%	4800	TKPH	80	5	Mt	3.61	3.55
LHD - 10t	83%	67%	4800	TKPH	40	4			
LHD - 7t	83%	67%	4800	TKPH	32	6			
Drill Jumbo	75%	25%	1620	TKPH	55	15	Km	16	15.5
Prod. Drill	75%	35%	2268	TKPH	35	6	Km	476	467

11.12.3 Mining Personnel

Mine	Mine Manager	Mining Engineer	Geologist	Skilled Labour	Unskilled Labour
Mochia	1	46	6	1041	173
Balaria	1	43	6	797	124
Zawarmala	1	31	3	430	20
Baroi	1	44	6	1267	161
Total	**4**	**164**	**21**	**3535**	**478**

11.12.4 Mine Ventilation

11.12.4.1 Mochia Mine

A long-term study for ventilation requirement for future expanded mine has been carried out through Indian School of Mines, Dhanbad to determine the ventilation fan and airway size considering population of major mining equipment's, air requirement for diesel emission dilution and manpower deployed. Mochia & Balaria mine are connecting mines and share their ventilation circuit. Therefore, entire ventilation study & design has been made considering it as single entity as Mochia-Balaria complex.

The Mochia-Balaria complex has 6 nos. intake namely Central Mochia shaft, Adit 5 & West Mochia shaft, Mochia-Balaria Portal at Mochia mine; and Adit-5, Adit 4 & Balaria shaft and Balaria production Incline at Balaria mine. Complex has 6 exhaust fans namely Adit 4 fan (150+60=210 Cu.m/Sec), Rawa adit fan (90 Cu.m/sec) at Mochia mine and Adit 8 fan (150+150+60=360 Cu.m/Sec), at Balaria mine and connected with ventilation raises in between levels. Long ventilation raises are planned using raise borer for effective ventilation. For improving the intake air quantity two long raises planned for which piloting has been completed and remaining will be done in FY 21-22. Two fans at Rawa Adit and one fan at Adit-4 of 150cu.m/sec each capacity are planned to increase the exhaust air capacity.

Mine air is being regulated using ventilation door, stoping wall, brattices, secondary ventilation fan, booster fan etc. Exhausted stopes are being sealed-off by constructing stoping wall (i.e., complete or with provision of door) at stope entry point or at drawl cross-cuts.

The ventilation quantity is accessed based on ventilation requirement for Diesel Equipment's planned to be deployed considering DGMS norms. Equipment's KWH is considered for estimating overall KWH running at mine. The ventilation provision for Crusher & Workshop installation also been considered. At the full production rate, maximum total primary air requirement has been estimated to be ~711m^3/sec as tabulated below

Table 53: Ventilation requirement at Mochia Mine

Operating Equipment	kW	2024-25		
		no.	Total kW	Air Req @0.06cu. m/s/kW
LPDT 60t	567	8	4536	269
LPDT 30t	310	4	1240	58
LPDT 20t	240	5	1200	58
LHD 15/17 tonne	276	7	1932	128
LHD 10 tonne	220	8	1760	96
LHD 6-7 tonne	150	2	300	15
Sub-Total	**2175**	**34**	**10968**	**624**
Conveyor, Crusher & Workshop			m3/m	20
		Total Air Required	**m3/m**	**644**

Table 54: Main Intakes and Returns

Main Intake	Size	Present (Qty)	Proposed (Qty)
Mochia Mine			
Central Mocia shaft	5.2m x 3.8m	120 Cum/sec	120 Cum/sec
Adit - 5 West Mochia shaft		110 Cum/sec	110 Cum/sec
Mocia Decline	5.5m x 5m	160 Cum/sec	160 Cum/sec
West Mochia Intake Raisebore	3.5m dia		120 Cum/sec
Central Mochia Intake Raisebore	3.5m dia		150 Cum/sec
Balaria Mine			
Adit 4 - Balaria shaft	3.6m dia	70 Cum/sec	80 Cum/sec
Production Incline	3.4m x 2.3m	30 Cum/sec	30 Cum/sec
Balaria Decline	5.5m x 5m	100 Cum/sec	100 Cum/sec
Intake Raisebore	3.5m dia		130 Cum/sec
Adit 1	3m x 3m		70 Cum/sec
Adit 5	3m x 3m	70 Cum/sec	100 Cum/sec
Total Mochia Balaria Complex		**660 Cum/sec**	**1170 Cum/sec**

11.12.4.2 Balaria mine

A long-term study for ventilation requirement for future expanded mine has been carried out through Indian School of Mines, Dhanbad to determine the ventilation fan and airway size considering population of major mining equipment's, air requirement for diesel emission dilution and manpower deployed. Mochia & Balaria mine are connecting mines and share their ventilation circuit. Therefore, entire ventilation study & design has been made considering it as single entity as Mochia-Balaria complex. The Mochia-Balaria complex ventilation has been covered in Mochia mine ventilation section 2B.1 viii).

The Balaria mine has 5 nos. intake namely Adit 4 & Balaria shaft, Adit no 5, Balaria Decline, Balaria production Incline and through Mochia haulage. Mine has 3 nos. exhaust fans namely Adit 8 fan (60 Cu.m/Sec), Two howden fan (150 Cu.m/Sec) each connected with ventilation raises in between levels. Scheme of Ventilation for Balaria mine is depicted in Ventilation Layout plan (Plate B14).

Long ventilation raises are planned using raise borer for effective ventilation. West Balaria Adit 8 exhaust raises (2 Nos. – 3.5 m Ø) has been completed from 378 to 70mRL and two fan installation is completed. New Exhaust raise of 3.5m dia with 150cu.m/sec capacity fan is planned near Adit-1 to further enhance the ventilation capacity and a new intake raise is also planned to incorporate the same.

Mine air is being regulated using ventilation door, stoping wall, brattices, secondary ventilation fan, booster fan etc. Exhausted stopes are being sealed-off by constructing stoping wall (i.e., complete or with provision of door) at stope entry point or at drawl cross-cuts.

At the full production rate, maximum total primary air requirement has been estimated to be ~497m³/sec as tabulated below –

Table 55: Ventilation requirement at Balaria Mine

Operating Equipment	kW	2024-25		
		no.	Total kW	Air Req @0.06cu. m/s/kW
LPDT 60t	560	5	2800	168
LPDT 20t	240	11	2640	158
LHD 15/17 tonne	305	3	915	55
LHD 10 tonne	200	5	1000	60
LHD 6-7 tonne	150	4	600	36
Sub-Total	**2300**	**28**	**7955**	**477**
Conveyor, Crusher & Workshop			m3/m	20
Total Air Required			**m3/m**	**497**

11.12.4.3 Zawarmala mine

A long-term study for future ventilation requirement has been carried out through Indian School of Mines, Dhanbad to determine the ventilation fan and airway size considering population of major mining equipment's, air requirement for diesel emission dilution and manpower deployed.

The Zawarmala mine has two intakes through Adit 3 (430mRL) & old incline followed by UG Shaft, Ramp and intake raise to bottom level. Mine has one exhaust fan at Adit 2 fan (150 Cu.m/Sec) and connected with ventilation raises in between levels. Scheme of Ventilation is depicted in Ventilation Layout plan (Plate Z12A).

Mine air is being regulated using ventilation door, stoping wall, brattices, secondary ventilation fan, booster fan etc. Exhausted stopes are being sealed-off by constructing stoping wall (i.e., complete or with provision of door) at stope entry point or at drawl cross-cuts.

At the full production rate, maximum total primary air requirement has been estimated to be ~283m³/sec as tabulated below

Table 56: Estimated Air Requirements - Zawarmala

Operating Equipment	kW	2024-25		
		no.	Total kW	Air Req @0.06cu. m/s/kW
LPDT 42t	460	2	920	55
LPDT 20t	194	6	1164	70
LHD 10 tonne	200	2	400	24
LHD 6-7 tonne	129	5	645	39
Diesel Locomotive	90	1	90	5
Sub-Total	**2265**	**16**	**3219**	**193**
Conveyor, Crusher & Workshop			m3/m	20
Total Air Required			**m3/m**	**213**

Table 57: Proposed Air intake / return capacity - Zawarmala

Main Intake	Size	Present (Qty.)	Proposed (Qty.)
Adit 3	4m x 3m	79 Cu.m/Sec	89 Cu.m/Sec
Old Incline	-	64 Cu.m/Sec	131 Cu.m/Sec
G.Total – Zawarmala		**143 Cu.m/Sec**	**220 Cu.m/Sec**
Main Exhaust	**Size**	**Present (Qty.)**	**Proposed (Qty.)**
Adit 2 fan	4m x 3m	144 Cu.m/Sec (300mmwg)	220 Cu.m/Sec (+300mmwg)

11.12.4.4 Baroi Mine

A long-term study for ventilation requirement for future expanded mine has been carried out through Indian School of Mines, Dhanbad to determine the ventilation fan and airway size requirement considering population of major mining equipment's, air requirement for diesel emission dilution and manpower deployed.

The Baroi mine has 4 nos. intake namely Central Baroi Ramp, Adit 1, North Baroi Ramp and Main Decline. Mine has 4 exhaust fans installed at Adit 3 (60 Cu.m/Sec) at Central Baroi, Adit 2 (150 Cu.m/sec) at North Baroi, Central Baroi Raise bore (150 Cu.m/sec) and Haran Magra UG Fan (70 Cu.m/sec) are connected with ventilation raises in between levels. Scheme of Ventilation for Baroi mine is depicted in Ventilation Layout plan (Plate Br18).

Long ventilation raises are planned using raise borer for effective ventilation. At Haran magra, fan chamber development is in progress and one raise boring is planned from 390 to 305mRL and ventilation fan of 150Cu.m/sec fan is plan to be installed for increasing further ventilation. For further improving the underground environmental condition multiple long intake raises have been developed along with inter level raises connection to maintain fresh air up to the bottom of the working.

Mine air is being regulated using ventilation door, stoping wall, brattices, secondary ventilation fan, booster fan etc. Exhausted stopes are being sealed-off by constructing stoping wall (i.e. complete or with provision of door) at stope entry point or at drawl cross-cuts.

At the full production rate, maximum total primary air requirement has been estimated to be ~544m³/second (2024-25) as tabulated below –

Table 58: Estimated Air Requirements - Baroi

Operating Equipment	kW	2024-25		
		no.	Total kW	Air Req @0.06cu. m/s/kW
LPDT 60t	567	7	3969	238
LPDT 30t	310	2	620	37
LPDT 20t	240	8	1920	115
LHD 15/17 tonne	276	5	1380	83
LHD 10 tonne	220	4	880	53
LHD 6-7 tonne	150	2	300	18
Sub Total	1850	28	9069	544
Total Air Required			**m3/m**	**544**

Table 59: Proposed Air intake capacity – Baroi

Main Intake	Size	Present (Qty.)	Proposed (Qty.)
Central Baroi Ramp	4m x 3m	90 Cu.m/Sec	90 Cu.m/Sec
North Baroi Ramp	4m x 3m	90 Cu.m/Sec	134 Cu.m/Sec
Main Decline	5.5m x 5m	170 Cu.m/Sec	190 Cu.m/Sec
Adit 1 _Central Baroi	3.6m x 3m	80 Cu.m/Sec	130 Cu.m/Sec
G.Total – Baroi mine		**430 Cu.m/Sec**	**544 Cu.m/Sec**

12 Processing and Recovery Methods

12.1 Introduction

The ROM ore from the four mines comprising the Zawar mining complex is treated at a central mineral processing plant located in the main administrative area close to the Mochia and Balaria mines.

The mineral processing consists of:

- transportation of ROM ore to the processing facility,
- communition (crusher and grinding),
- concentration (floatation),
- drying of concentrate (thickening and filtration).
- dispatch of concentrate to smelter(s), and
- transportation of rejects (tailings) to a tailings storage facility.

Separate Pb+Ag and Zn concentrates are produced. Smelting and refining are done at captive metallurgical complexes of HZL.

The processing plant consist of two independent assemblies:

- “Mill 1” has capacity to treat 2.7 Mtpa - this plant is the older of the two.
- “Mill 2” has capacity to treat 2.0 Mtpa. Mill 2 was commissioned in March 2019.

Plans are being developed to increase the capacity of Mill 2 to 2.5 Mtpa through a de-bottlenecking exercise.

The main ore minerals at Zawar are, in order of abundance: sphalerite, pyrite and galena, although at Baroi galena is the predominant base metal sulphide mineral. Typical plant feed characteristics are summarised in table below.

Table 60: Typical physical characteristics of ROM ore feed at Zawar

ROM Ore Characteristics	Value
Average moisture content	2% (Maximum 5%)
Angle of Repose	35 degrees
Bulk Density for designing purpose	1.8 MT/M3
Bond Work Index	9.5 KWH/ST
Specific Gravity of Ore	2.85
Compensated Work Index	11.8
Chemical Composition of Feed Ore	**Value**
% Lead in feed	1.95% +/- 0.5%
% Zinc in feed	3.18% +/- 0.5%
Ag in feed	30 – 40 ppm
% Fe in feed	5% - 6%

12.2 Process Flow maps

Ore from the various mines undergo a primary stage of crushing at the mines (either underground or at surface close to the portals) to produce a coarse product (-150 mm). The coarse product is transported by belt conveyor or tipper trucks to the coarse ore stockpile ("COSP") at the centralised processing plant. Secondary crushing reduces particle size to -12 mm ("fine ore").

The fine ore is comminuted further by grinding in ball mills to -106 µm, which is the particle size require for optimal liberation of the target minerals.

Concentration of metals from the milled ore is by sulphide floatation. Zawar mines typically have less than 1% graphite in the ROM ore, and no allowance is made in the floatation circuit for removal of graphite. A lead (with silver) concentrate is floated off first, followed by a zinc floatation.

The lead and zinc concentrates are thickened and filtered to produce a dry concentrate cake that is transported by trucks to the HZL smelters.

Schematics of the process flows for Mill 1 and Mill 2 are shown in figures below.

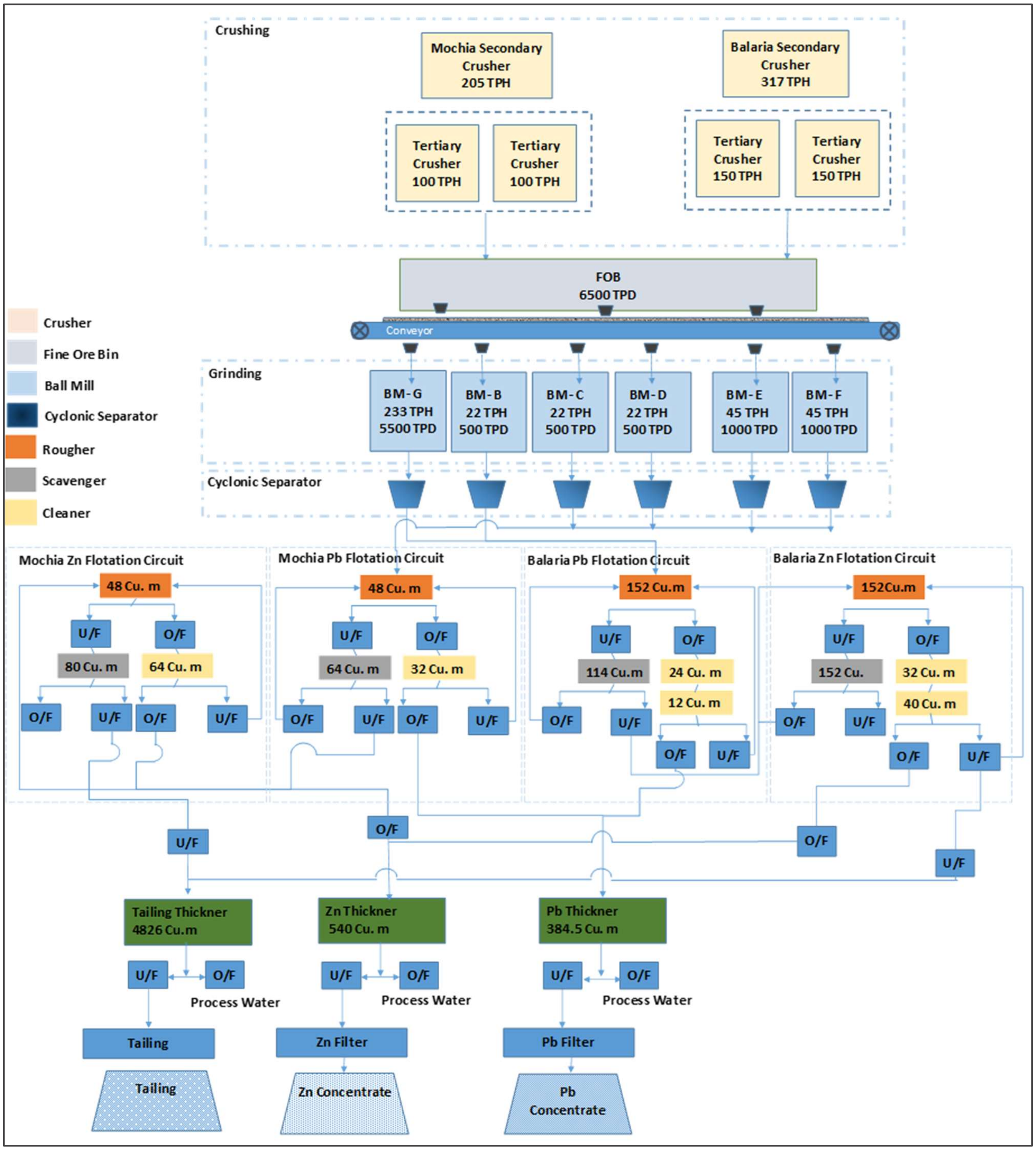


Figure 33: Schematic Process Flow Sheet for Mill 1 – 2.7 Mtpa

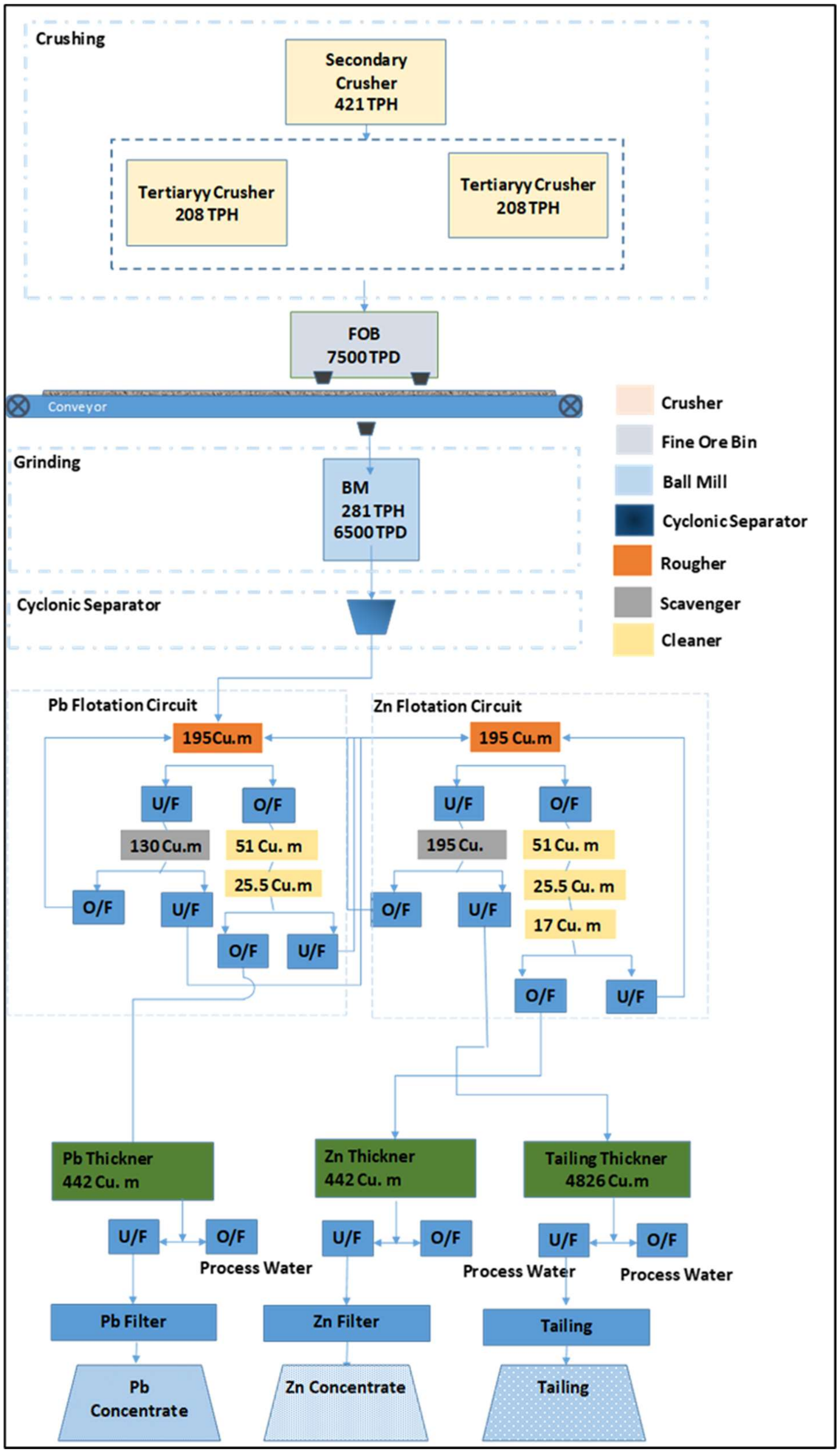


Figure 34: Schematic Process Flow Sheet for Mill 2 – 2.0 Mtpa

12.3 Crushing, Screening, Ore flow

The routing of ore from the mines to the processing plant is accomplished through several combination of transport and crushing:

- Mochia mine ore may follow one of two routes:
  - some ore undergoes primary crushing underground and is then hoisted by vertical shaft to surface form where it is transported by conveyor belt to the processing plant; and
  - some ore is transported from underground to surface by low profile dump trucks (LPDTs) via a ramp and portal shared with Balaria mine be co-crushed with Balaria ore at a primary crusher located near the portal. From the crusher the coarse ore is transported by belt conveyor to the processing plant.
- Balaria mine ore may follow one of two routes:
  - some ore undergoes primary crushing underground and is transported by inclined conveyor belt to surface form where it is transported by another conveyor belt to the processing plant; and
  - some ore is transported from underground to surface by LPDTs via a ramp and portal shared with Mochia mine be co-crushed with Mochia ore at a primary crusher located near the portal. From the crusher the coarse ore is transported by belt conveyor to the processing plant.
- Baroi mine ore is transported by LPDTs via a ramp to a primary crusher located close to the portal. From here it is transported to the processing plant by tipper trucks.
- Zawarmala mine ore undergoes primary crushing underground and is then transported to surface by a combination of LPDTs and locomotive-drawn Granby cars (side discharge wagons). From the ore bunker at the portal, ore is transport to the processing plant by tipper trucks.

Surface transport by tipper trucks (14 t to 35 t capacity) on all weather roads from Baroi and Zawarmala mines cover one-way distances of 6 km and 8 km respectively.

At the COSP, ore is temporarily stacked in designated stockpiles namely Mochia, Balaria & Mill 2 stockpiles.

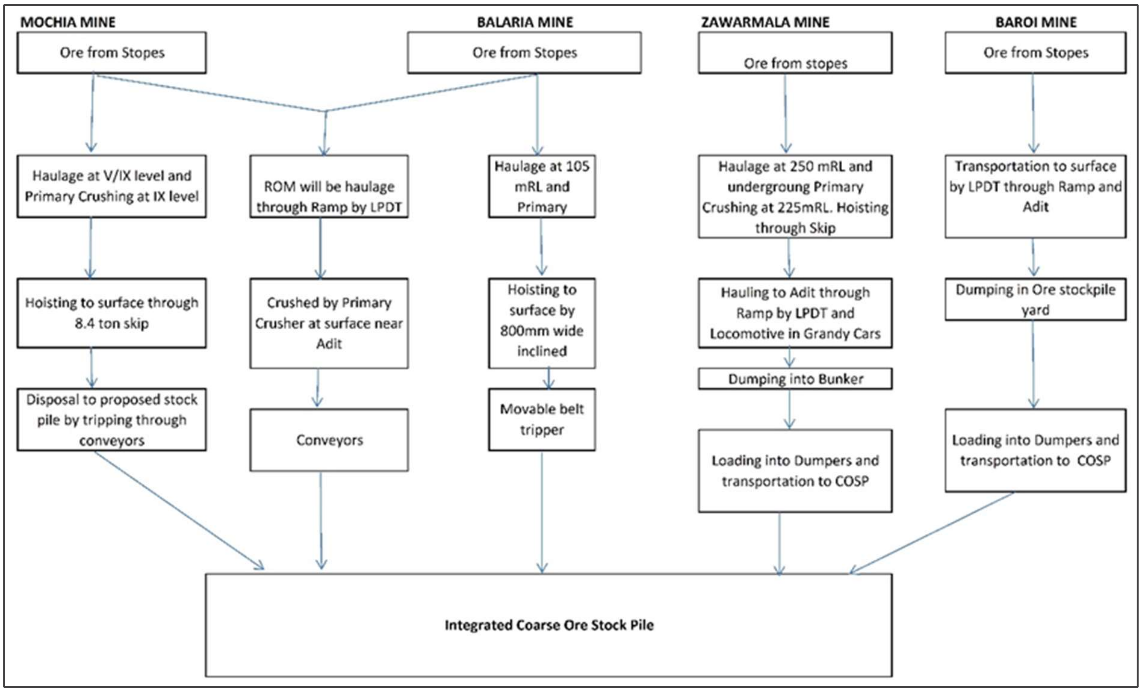


Figure 35: Diagram showing ore transportation from the various mines to the processing plant

The three streams of material created at the COSP, being from the Mochia, Balaria & Mill 2 stockpiles, are treating separately, although the processes are similar for each circuit.

The primary crushed ROM (-150 mm) from the COSP is fed to a double deck (-50 mm and -12 mm) scalping screen. Screen oversize (+50 mm) is fed to the secondary crusher and screen under sizes (-50 mm and -12 mm) are fed to the tertiary crusher and fine ore bin ("FOB") respectively. The secondary crusher output (-50 mm) is fed to the tertiary crusher via another 12 mm screen (tertiary screen). Screen undersize (-12mm) is fed to the FOB through belt conveyors. Tertiary crusher oversize output is recycled back to tertiary screen & crusher. The crushing circuits and their capacities are summarised in table below.

Table 61: Secondary and tertiary crusher capacities at Zawar mines

Equipment	Mill 1: Mochia Crusher	Mill 1: Balaria Crusher	Mill 2 Crusher
Overall Secondary Crushing capacity	1.2 Mtpa	1.6 Mtpa	2.0 Mtpa
Secondary Crusher	205 tph x 1	317 tph x 1	421 tph x 1
Tertiary Crusher	100 tph x 2	150 tph x 2	208 tph x 2
Fine Ore Bin capacity	6500 t		7500 t

The fine ore (-12 mm) is fed to the ball mills by means of disc & belt feeders for wet grinding, using high-chrome grinding media of 80 mm size. These ball mills operate in a closed circuit with hydrocyclones. The hydrocyclones are fed by cyclone feed pumps and yield (overflow) a product containing 80% of -150 mesh particle size i.e., -106 µm (micrometre or "microns"), which is the specific particle size desired for liberation of valuable minerals. The underflow goes back to the ball mill.

Ball mill shell liners are made up of manganese steel with wave-type male & female lock with liner keys.

The Mill 1 grinding section comprises a total of six ball mills with the following capacities:

- 1 x 5500 tpd ball mill,
- 2 x ball mills of 1000 tpd each, and
- 3 x ball mills of 500 tpd each.

i.e., a total ore treatment capacity of 9000 tpd (2.7 Mtpa).

The Mill 2 mill grinding section has one ball mill of 2 Mtpa capacity, resulting in a 4.7 Mtpa overall installed capacity.

12.4 Flotation

Lead (with silver) is floated off first in a dedicated floatation circuit, after which zinc is floated off in its own dedicated circuit.

12.4.1 Lead Floatation

The Mill 1 lead floatation section consists of two streams named Mochia and Balaria which have the same modes of operation. The lead floatation stream comprises roughing, scavenging and two stages of cleaning. The hydrocyclone overflow from the grinding feeds to the rougher cells. The rougher float goes through a two-stage cleaning process and the tails go to scavenger cells. The scavenger cell float is recycled back to the rougher cells for processing and tails are fed to the zinc floatation section. The second-stage cleaner concentrate is the final lead concentrate.

The Mill 1 - Mochia lead floatation consists of three rougher cells, four scavenger cells and a first cleaning stage of two cleaner cells with a second cleaning stage of one cleaner cell. Balaria lead floatation consists of four rougher cells three scavenger cells, and two cleaning stages with three and four cleaner cells respectively.

In the Mill 2 - 2 Mtpa plant the lead floatation circuit consists of three rougher cells and two scavenger cells. There are three cells in the first stage of cleaning and another three cells in the second-stage lead cleaning circuit.

The capacities sizes of the various lead floatation circuits are summarised in table below.

Table 62: Capacities and sizing of lead floatation circuits at Zawar

Equipment	Mill 1 – Mochia Pb floatation circuit	Mill 1 – Balaria Pb floatation circuit	Mill 2 – 2 Mpta Pb floatation circuit
Floatation capacity	1.2 Mtpa	1.6 Mtpa	2.0 Mtpa
Rougher cells	16 m^3 x 3	38 m^3 x 4	65 m^3 x 3
Scavenger cells	16 m^3 x 4	38 m^3 x 3	65 m^3 x 2
Cleaner cells	8 m^3 x 2 16 m^3 x 1	8 m^3 x 3 3 m^3 x 4	17 m^3 x 3 8.5 m^3 x 3

Lead floatation recovery averages 90%.

12.4.2 Zinc Floatation

The Mill 1 - Zinc floatation section also contains two streams named Mochia and Balaria, both having the same mode of operation. The zinc floatation section treats the lead scavenger tails and the circuit comprises roughing, scavenging and three stages of cleaning. The lead scavenger tails are fed to the zinc rougher cells. The zinc rougher cells concentrate (float) is fed to a three-stage cleaning process and the tails are fed to scavenger cells. The scavenger cell float is fed back to the rougher cell and the tails are directed to tailings storage.

The Mill 1 – Mochia zinc floatation section consists of three rougher cells, five scavenger cells and a single stage of eight cleaner cells. Balaria zinc floatation consists of four rougher cells, four scavenger cells, and two stage of cleaning. The first cleaning stage has two cleaner cells and the second has five cleaner cells.

In the Mill 2 - 2 Mtpa plant the lead floatation circuit comprises three rougher cells, three scavenger cells and a three-stage cleaning circuit. The first stage of cleaning has three cells, the second also has three cells and the final stage has two cells.

The capacities sizes of the various lead floatation circuits are summarised in table below.

Table 63: Capacities and sizing of zinc floatation circuits at Zawar

Equipment	Mill 1 – Mochia Zn floatation circuit	Mill 1 – Balaria Zn floatation circuit	Mill 2 – 2 Mpta Zn floatation circuit
Flotation Capacity	1.1 Mtpa	1.7 Mtpa	2.0 Mtpa
Rougher cells	16 m^3 x 3	38 m^3 x 4	65 m^3 x 3
Scavenger cells	16 m^3 x 5	38 m^3 x 4	65 m^3 x 3
Cleaner cells	8 m^3 x 8	16 m^3 x 2 8 m^3 x 5	17 m^3 x 3 8.5 m^3 x 5

Zinc floatation recovery averages 92%.

12.5 Concentrate Thickening and Filtration

Lead and Zinc concentrates are sent to their respective high rate thickeners ("HRTs"). Overflow from thickeners is collected in suitable tanks having suitable drain arrangement with drain valve for recirculation and the deposited metal concentrate is collected and fed to the filtration units utilising drum filters. Recovered water is returned to the process water tank.

The Mill 1 lead concentrates (Mochia and Balaria) are combined and treated in the same thickening and filtration circuit. Likewise for the Mill 1 zinc concentrates. The Pb thickener has a volume of 384.5 m^3 and diameter of 12 m; the Zn thickener volume has a volume of 540 m^3 and diameter of 15 m. Two drum filter of 8 ft by 16 are utilised for the Zn concentrate and another identical two drum filters are used on the lead concentrate.

The Mill 2 lead and zinc concentrates are thickened in separate thickeners: both the Pb and Zn thickeners have volume of 577 m^3 and diameters of 15 m. Pb and Zn thickened concentrates are filter by 8 ft by 16 ft drum filters: two for lead and two for zinc.

Final concentrate grade averages ≥50% Zn and ≥60% Pb.

There are separate stockpiles for zinc and lead concentrates. The concentrates are dropped directly from conveyor belts on the respective stockpiles. Concentrates are sent by road to Dariba / Chanderiya Lead and Zinc Smelters for smelting.

12.6 Tailings, Thickening and Filtration

The tailings from Mill 1 and Mill 2 are sent to two separate tailing thickeners, each having a volume of 4826.3 m^3 (83 m diameter).

Some 10,000 m^3 of water is recovered from the overflow of the tailings thickeners and sent to a holding sump for re-utilisation in plant operation. The tailings from the underflow of the tailings thickeners are pumped to the dry tailing plant ("DTP"). There are three tailings disposal lines for Mill 1 and two tailing disposal lines for Mill 2. Each line is capable of handling the tailing generated from the processing plant, so that while one tailings line is in operation the other is in standby mode.

The dry tailings plant reduces the water content of the tailings to 15% moisture. The dry tailings material is transported by tipper trucks to selected deposit areas, where it is spread out in a compacted 300 mm thick layer. These layers are stacked and the sidewalls of the stack cladded with waste rock from underground development activities. Concrete drainage channels and ditches are constructed

Water recovered by the dry tailings plant is returned and re-used in the mill operations.

12.7 Reagents and Water

Reagents $ZnSO_4$, SIPX (sodium isopropyl xanthate), NaCN, $CuSO_4$, SMBS (sodium metabisulphite $Na_2S_2O_5$) and MIBC (methyl isobutyl carbinol) are used in the main process plant. The reagent system comprises of preparation tank and distribution tank. There are agitators in preparation tanks.

All reagents are added at required points with required dosages in the flotation circuits by use of flow meter and control valve in closed loop. There are suitable metering type dosing pumps for control of MIBC and SIPX flow.

The primary sources of processing water are:

- water pumped from the mines, and
- water pumped from the Tidi Dam (this dam is controlled by HZL).

Water is recovered for re-use at the following points:

- primary tailings thickener at the processing plant,
- concentrate thickeners, and
- secondary thickener at dry tailings plant.

12.8 Process Control Philosophy

Process control is semi-automated. Quality control samples are taken at regular time intervals and the results incorporated in the live display and control panels. Densities and particle sizing are similarly monitored. Mechanical performance, power draws, temperatures, etc., are also monitored in real time. The feedback loops are updating at least every 5 minutes. Live video of froths of all floatation cells are displayed in the control room. The metallurgical section has its own dedicated chemical laboratory to analyse its quality control samples, so turnaround times are relatively quick.

12.9 Conclusions and Recommendations

The ore at Zawar is well-behaved and responds very well to standard base metal processing methodology. The current processing plant operates efficiently and achieves very high recoveries of zinc and lead. Implementation of dry stacking of tailings has extended the capacity of the current tailings storage facility to safely hold tailings. Erosion and rabbit-holing were observed on the rock-clad sidewalls of the dry tailing stacks – this is not yet a threat but should be monitored and repaired from time to time.

12.10 Risks and Opportunities

A project has started to assess increasing the capacity of the Mill 2 circuit from 2 Mtpa to 2.5 Mtpa by de-bottlenecking of the current setup and installing an additional 40 tph ball mill.

The possibility of installing a single ball mill of 2 Mtpa capacity with matching floatation circuits and concentrate thickening and filtration equipment near North Baroi is also being investigated. Tailings HRT, filters and pumping system will be installed based on the existing 2 Mtpa plant design.

13 Primary Surface Infrastructure

13.1 Roads

The Zawar group of mines is located within hilly area & marked by rugged and hilly terrain, dominated by steeply dipping outcrops and small valleys carved by the networks of ephemeral streamlets and streams. The drainage pattern is subdendretic to dendritic. The general slope of the area is from west to east and northwest to southwest. In the northern and western part of the area, there are some high peaks of the hills. The southeastern part has comparatively lower elevation having lowest elevation i.e., at Khakhadara. The major part of these hilly areas is under forest cover. Access to the mines is adequate from the local villages and to major motorway infrastructure. The Complex is located between two major motorway that connect that travel to Udaipur.

13.2 Tailings Disposal

A feasibility study has been conducted by M/s Tata Consulting Engineering Limited for dry disposal (cake) of tailing over existing tailing dam instead of present practice of wet disposal. Further Geo-tech bore hole drilling for the stability of existing dam to cater to the increased load of dry tailing has been carried out and study suggest that this as a viable option. The proposed scheme carries filtration of tailing slurry using tailing filter plant, to produce cake having 16-18% moisture and disposing to tailing dam. This option will enable us for lesser land requirement for new tailing dam construction. Due to reclaiming water from tailing slurry, the possibility of tailing dam failure will be reduced as pore water pressure will be less.

In this process, the filtration plant consists of Thickener & Disc filtration units. bottom feed arrangement shall be made for uniformly distribution of feed slurry. Filtration plant shall produce cake having 16-18% moisture content. Cake from the filtration unit will be conveyed using belt conveyor to an intermediate stockpile. One common belt conveyor shall be collecting cake from different filtration units. The stockpile shall have 8 hours' stock capacity. The cake will be disposed of to the tailing dam using conveyor, dumper & dozer combination, which shall be continuously compacted using the compactor / roller. Water from filter unit shall be collected into a tank and pumped back to beneficiation plant for reuse. Fresh water shall be required for vacuum sill water for feed pump. One small portion of existing tailing dam shall be kept aside for direct wet disposal of tailings to serve during transition period or handling emergency breakdown of filtration plant.

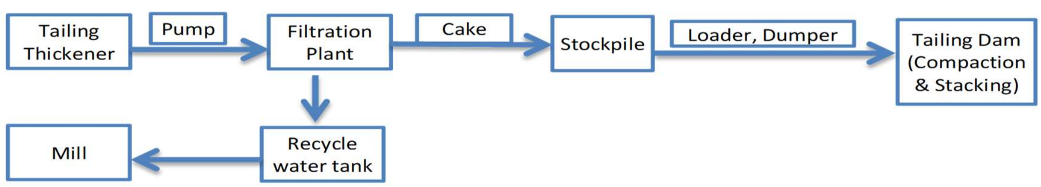


Figure 36: Flowsheet - Tailings disposal

Options of new tailing dam has been evaluated for meeting the future requirement of lease period. The old tailing dam and near old tailing dam storage area combine is identified sites for new tailing dam construction with dry stacking tailing disposal. Forest land diversion is envisaged for tailing dam construction in these areas and application is submitted for the same.

The Authorization for operating a facility for collection, disposal, Generation, Reception, Storage of Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008 has been granted vide letter no. F(HSW)/Udaipur(Girwa)/2544(1)/2015-16/9047-9049 dated 22.03.2016 is in place.

13.3 Power and Water

13.3.1 Power

The power is supplied by coal based 92MW Captive power plant through AVVNL grid and distributed to mines & beneficiation plant via various sub-stations at Zawar Mines. In case of any supply power failure, additional stand by 6MW DG set or AVVNL grid shall provide power. The present power requirement is around 20MW and will be increased to around 35MW during Mining Plan period.

13.3.2 Water

Water supply is being made from Tidi Dam (MoU with State Govt.) through pipe line. Tidi dam is Gravity Masonry Dam constructed in 1976 at Amarpura village situated approximately 15 kms from Zawar Complex. It has 300 mcft capacity and surplus capacity of water at Tidi dam available for the proposed Mine Plan.

14 Market Studies

14.1 Introduction

Hindustan Zinc (HZL) is India's largest and world's second largest zinc-lead miner. With more than 50 years of operational experience, they have a reserve base of 161.2 million MT and an average zinc-lead grade of 5.9% and mineral resources of 286.7 million MT, our mine life is over 25 years. Their fully integrated zinc operations hold 78% market share in India's primary zinc industry, and they are the 6th largest silver producers globally with an annual production of 913,000t.

The market was negatively impacted by COVID-19 in 2020 and 2021. Considering the pandemic scenario, the construction activities were stopped temporarily during the lockdown to curb the spread of new COVID-19 cases, thereby decreasing the demand for zinc and lead-based products such as galvanised metal, lead sheets, and others from the construction industry. Furthermore, the demand for lead-acid batteries decreased due to the temporary pause of the automotive manufacturing units during the lockdown. However, the demand for lead-acid batteries, especially valve-regulated lead-acid (VRLA) batteries, from the electronics and telecommunication industry increased during this period, as people opted to work online from their residence, which enhanced the demand in the market studied. With the lifting of restrictions, companies are keen to see a return to pre-2020 levels of activity.

14.2 Zinc

14.2.1 Application Of Zinc

Approximately 14% is used in the production of zinc die casting alloys. Nearly 9% of the zinc is utilized for oxides and chemicals and approximately 10% is used in alloys and castings. Some of the most common applications of zinc are listed below:

- **Galvanising**: Zinc offers one of the best forms of protection for steel against corrosion. It is used extensively in building & construction, infrastructure, household appliances, automobiles, steel furniture and other applications where lasting steel products are required.
- **Zinc Oxide**: The most widely used zinc compound, zinc oxide is used in the vulcanisation of rubber, as well as in ceramics, paints, animal feed, pharmaceuticals and several other products and processes. A special grade of zinc oxide has long been used in photocopiers.
- **Die Castings**: Zinc is an ideal material for die casting and is extensively used in hardware, electrical equipment, automotive and electronic components. Zinc die cast alloys are used in production of highly durable and visually appealing hardware fittings.
- **Alloys**: Zinc is extensively used in making alloys, especially brass, which is an alloy of copper and zinc.

14.2.2 Supply and Demand

The price of zinc is driven mostly by these five factors:

- Chinese Demand
- Chinese Supply
- Global Stocks
- US Demand

As with most industrial commodities, China plays a pivotal role in determining zinc prices. China is the top consumer of refined zinc used in galvanized steel. Therefore, a key indicator of zinc demand in China and elsewhere is steel demand. Decisions about whether to undertake or hold off on infrastructure projects can create huge fluctuations in steel demand. Ultimately, these decisions can flow through to the zinc market. A key factor impacting zinc output in China is the country's increasing environmental awareness. Poor air quality has forced the government to take a harder look at the mining industry as a contributor to pollution. If China curbs the production of zinc to deal with this problem, then the country will be more reliant on imports. This could drive prices higher. The London Metals Exchange (LME) keeps track of global stock levels for zinc and other industrial metals.

Current world production is approximately 13 million tonnes. HZL produces approximately 913,000t of zinc per year and is well established in the market.

Table 64: HZL Product Range

Product	Form	Weight
Special High Grade (SHG)	Standard Ingot	25 kgs
	Jumbo Ingots	1000kgs
Continuous Galvanising Grade (CGG)	Jumbo Ingots	1000kgs
High Grade (HG)	Standard Ingot	25 kgs
	Jumbo Ingots	600 kgs
Prime Western (PW)	Standard Ingot	25 kgs
Electro-Plating SHG (EPG SHG)	Standard Ingot	25 kgs
Hindustan Zinc Die-Cast Alloy (AZDA)	Standard Ingot	9 kgs

14.2.3 Prices

As with all commodities, prices fluctuate. Prices in general are Zinc price predictions from the leading international agencies for the next few years are as follows:

- **The World Bank** in its commodity forecast report estimated that the average spot price for zinc will fall to $2,400 per metric ton (t) in 2022, down from $2,700/t at the end of 2021. After that, a slow growth period will start.
- **The IMF**'s report indicated a completely different expectation: a rise from $2,828/t in the end of 2021 to $2,859 in 2022. For the following period, IMF experts expect a smooth, gradual decline. They predict the price will drop to $2,818/t by 2026.
- **The Industry Innovation and Science Australia**’s prediction is like the World Bank's predictions: they expect a decrease in the zinc spot price from $2,686 at the end of 2021 to $2,362 in 2022, with further slow increase through 2026.
- HZL is using prices as projected by LME as listed below:

Table 65: HZL Financial Model Prices

Particulars	UOM	FY'23	FY'24	FY'25	FY'26	FY'27	FY'28	FY'29	FY'30	FY'31	FY'32	Average
LME - Zinc	$/MT	3,183	2,911	2,684	2,621	2,658	2,706	2,706	2,706	2,706	2,706	2,759
- Lead	$/MT	2,179	2,047	1,974	1,962	1,997	2,082	2,082	2,082	2,082	2,082	2,057
- Silver	$/Troz	22.19	20.47	21.61	21.33	21.30	21.10	21.10	21.10	21.10	21.10	21.24
Ex Rate	Rs/USD	74.94	75.43	76.52	77.73	78.64	79.11	79.51	79.51	79.51	79.51	76.65

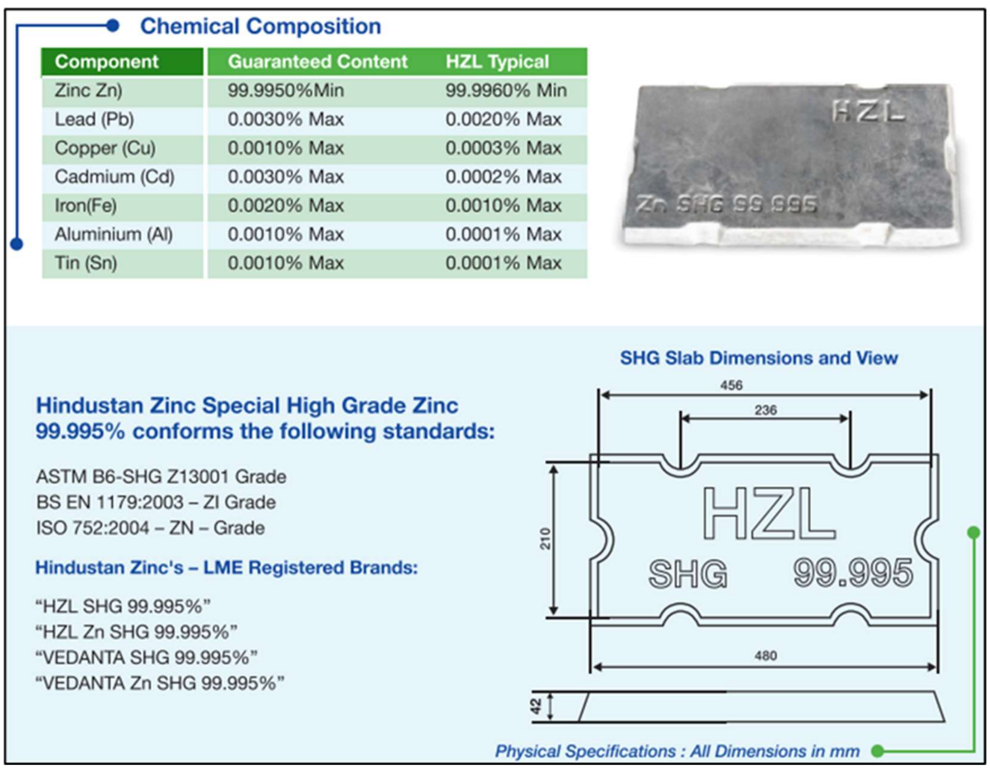
The figure below displays the price for zinc over the last five years. The price projections above agree in general with the historic average prices although it has been as low as US$1,500/t in January 2016 and as high as US$ 4,000/t in April 2022. In our opinion, the recent high price may be because of stock shortages created by the pandemic. These high levels are not sustainable, and we already see a substantial drop in prices which should stabilise at the levels projected by the LME, World Bank and others.

Figure 37: 5-Year Zinc Price in US Dollars

Source: Trading Economics

Figure 38: LME Zinc Contract Prices

Source: LME Website 12 July 2012.


Chemical Composition

Component	Guaranteed Content	HZL Typical
Zinc Zn)	99.9950%Min	99.9960% Min
Lead (Pb)	0.0030% Max	0.0020% Max
Copper (Cu)	0.0010% Max	0.0003% Max
Cadmium (Cd)	0.0030% Max	0.0002% Max
Iron(Fe)	0.0020% Max	0.0010% Max
Aluminium (Al)	0.0010% Max	0.0001% Max
Tin (Sn)	0.0010% Max	0.0001% Max

Figure 39: HZL Zinc Specifications

14.3 Lead

14.3.1 Applications for Lead

The battery sector is the single largest consumer of lead, accounting for around three-quarters of the demand. It can be sub-divided into the following groups:

- **SLI (Starting-Lighting-Ignition) batteries**, which currently accounts for over half of the total lead demand. These are mainly used in cars and light vehicles but are also found in other applications such as golf carts and boats. SLI battery demand in turn can be split into original equipment and replacement, with replacement demand outstripping original equipment demand by about 4:1 in mature markets.
- **Industrial batteries**, which currently consumes around a quarter of the total lead produced. This sector can be split roughly 50:50 into stationery and traction batteries. Stationary batteries are principally used in back up power supply systems; traction batteries are used for motive power in equipment such as forklift trucks and motorised wheelchairs.
- The remainder is used in non-battery applications. The second largest current end use of lead for non-battery applications, accounting for around 20% of lead consumption, is the alloys and chemical industry. Principal markets are for cathode ray tubes used in television screens and computer monitors, for Poly Vinyl Chloride (PVC) stabilisers and for making pigments for industrial use. Cable and other industries account for the remaining 5% of lead demand.

14.3.2 Supply and Demand

Growth in the construction industries was driving the overall market growth for a long time. High demand from renovation in the construction sector, including gutter and gutter joints and metal for roofing materials were propelling the market demand. Now, high demand for the electrical vehicle is influencing lead acid batteries demand emerging as the key driving factor for the market growth. Additionally, vigorous investment in improving telecom networks along with significant development in data centres are expected to enhance the industry position.

However, high production cost with stringent challenging processes is inhibiting the growth of lead market globally.

By the application segment, batteries segment is expected to dominate the market during the forecast period. As lead-acid battery is utilised in the form of stationary batteries, SLI batteries, portable batteries which includes electronics, consumers, telecom, energy storage system and others. SLI batteries have vast application in automobile designing and installation specifically with the automobile's charging system, that allow continuous cycle of charge and discharge in the battery each time the vehicle is in use. Furthermore, development in construction, machineries, and other battery dependent end-product is helping the market to grow.

Regionally, Asia Pacific is expected to dominate the lead market and is expected to grow during the forecast period. Developing countries like Japan, China, and India have boosted the market growth due to an increase in manufactures for machinery and tools across the world. This is expected to drive the market demand in this region.

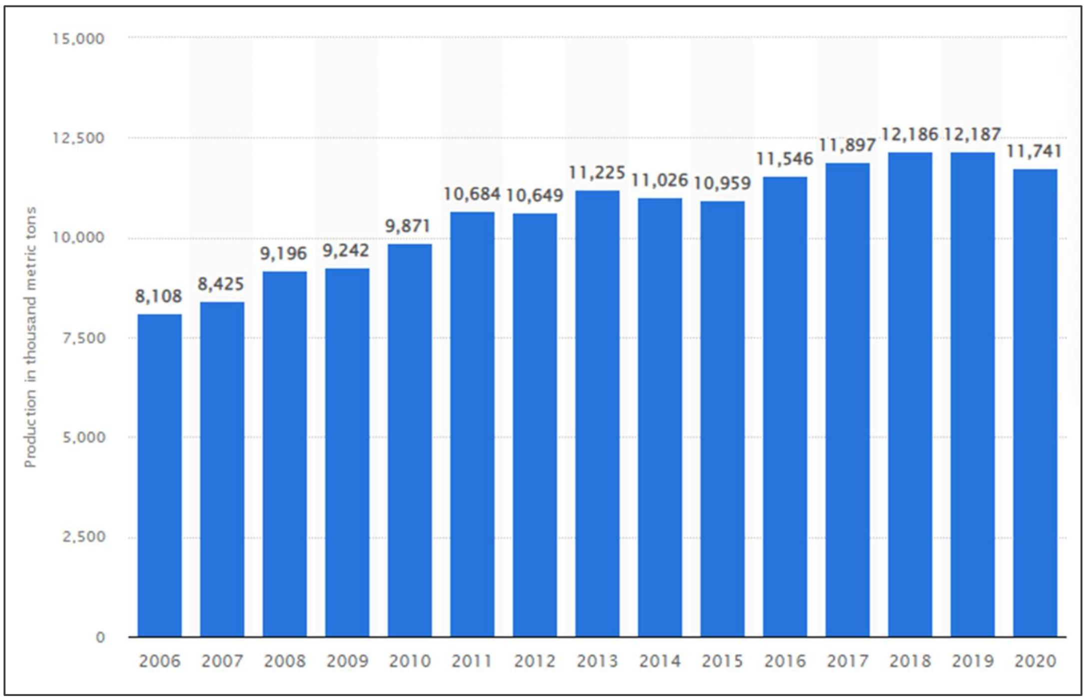


Figure 40: World Production of Lead

Figures above indicates a slow growth over the last 5 years with a slight dip in 2020, possibly due to COVID 19 restrictions. In our opinion, the production will recover and continue the slow growth of pre-pandemic years.

HZL produces lead ingots with a minimum of 99.99% purity which are registered with LME at a level of 210,000 t/a. This is expected to continue for the forecast period.

14.3.3 Prices

As with almost all commodities, prices are cyclical. Based on the 12-month price chart, there appears to be a severe reduction in price from around US$2,400/t to US$1,971 in July 2022. The 10-year price curve indicates that this is probably only a market correction. It is too early to guess at what level the price would stabilise.

Figure 41: 12-Month Price of Lead

Source – Trading Economics

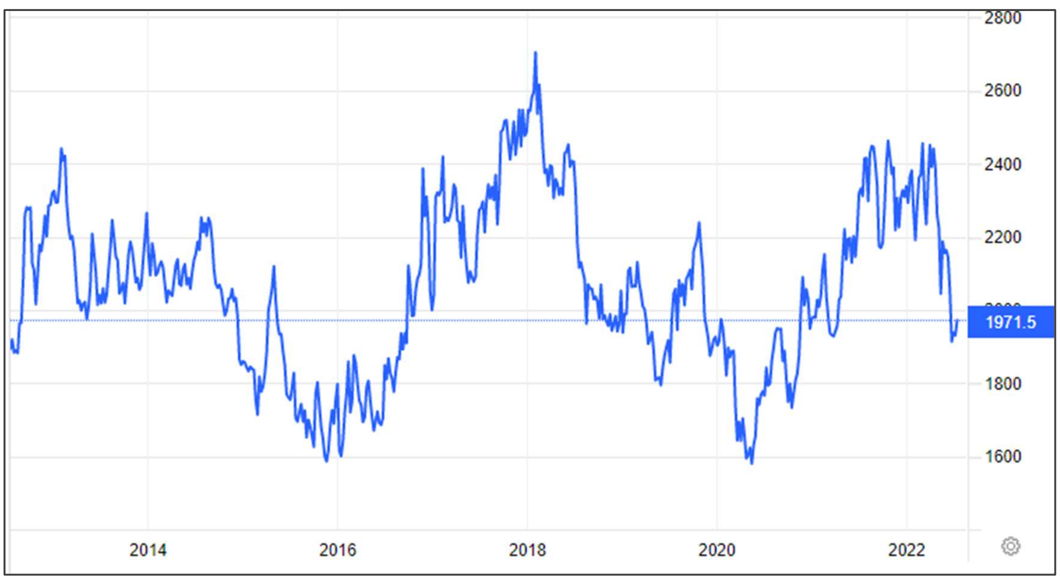


Figure 42: 5-Year Price of Lead

Source – Trading Economics

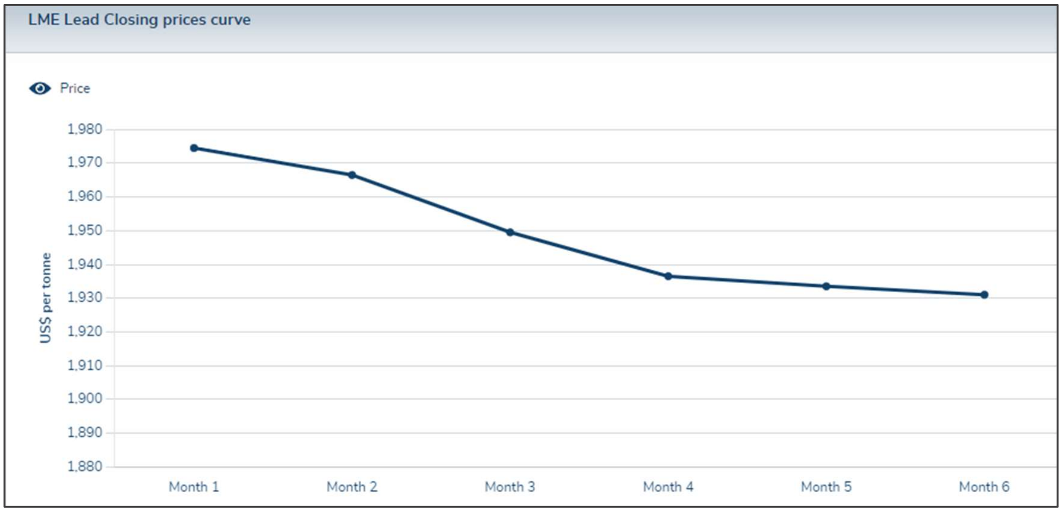


Figure 43: LME Contract Price on July 2022.

Source: LME July 2022

Chemical Composition **LME Brand : Vedanta 99.99**

Component	Composition- BS EN 12659 : 1999 PB990R	HZL Typical
Lead(Pb)	99.99% Min	99.993%
Silver(Ag)	0.0015% Max	<0.0005%
Arsenic(As)	0.0005% Max	<0.0003%
Bismuth(Bi)	0.0100% Max	<0.0050%
Cadmium(Cd)	0.0002% Max	<0.0002%
Copper (Cu)	0.0005% Max	<0.0005%
Nickel (Ni)	0.0002% Max	<0.0002%
Antimony(Sb)	0.0005% Max	<0.0005%
Tin (Sn)	0.0005% Max	<0.0005%
Zinc(Zn)	0.0002% Max	<0.0002%

Vedanta 99.99% (Bundle Specification)

Ingot Weight	25 Kg (+/- 1.2 Kg)
Ingot Dimensions	85 (+/-2)mm Width | 535(+/-2)mm Length | 75(+/-2) mm Height
Bundle Weight	1050 Kg (+/-50 Kg)
Bundle Configuration	6 ingots/layer x 7 layers | 42 ingots
Bundle Dimension	510(+/-12)mm Width | 535(+/-2) mm Length | 520(+/-14) mm Heig
Strapping	32 mm Tenax strap | 2*2 strapping

Vedanta 99.99 & Vedanta Pb 99.99- Hindustan Zinc Lead Ingots are LME Registere

Figure 44: HZL Lead Specifications

14.4 Silver

The extraordinary events of 2020 have had a profound effect on virtually all markets around the globe and silver has been no exception. The metal's supply/demand fundamentals, investment, prices, trade-flows and inventories have all experienced sensational fluctuations over the past 12 months or so. The effect of the pandemic is set to remain relevant to silver for some time to come. Several key silver mining countries were hit hard by lockdown restrictions, and global silver supply declined. This was more than offset, however, by losses across most of silver's physical demand segments, which suffered as a result of restrictions to economic activity as well as depressed consumer sentiment and/or income loss. This resulted in a large silver market surplus. One notable exception was physical investment. A growing appetite for safe haven assets and, initially, the strength of the gold price all boosted investors' appetite for silver bars and coins last year, culminating in an 8% rise overall.

14.4.1 Applications for Silver

Silver metal has been known since ancient times for its brilliant white metallic lustre with high ductility and malleability properties. The precious metal has varied uses backed by its excellent heat and electrical conductivity levels.

In India, the highest usage of silver is in jewellery, followed by coins & bars silverware and industrial fabrication. With growing Indian economy, silver demand especially in the industrial sector is expected to follow a healthy growth in the coming years with an increased off take especially in electrical and electronics as well as brazing alloys and solders.

14.4.2 Supply and Demand

According to the Silver Institutes report "World Silver Survey 2021", In 2020, global mine production suffered its biggest decline of the last decade, falling by 5.9% y/y to 784.4Moz (24,399t). This was caused by temporary mine closures in several major silver producing countries in the first half of the year as a direct result of the COVID-19 pandemic. Output from primary silver mines declined by 11.9% y/y to 209.4Moz (6,513t). This exceeded the drop that silver by-product output from lead-zinc and gold mines suffered, which fell by 7.4% to 248.3Moz (7,724t) and by 5.7% to 123.3Moz (3,834t), respectively. Countering this trend, silver production from copper mines increased by 3.5% y/y to 198.3Moz (6,169t).

At the county level, the largest declines were in nations which implemented COVID-19 lockdowns that required mines to temporarily halt operations. This led to substantially lower silver production in Peru (-26.1Moz, 810t), Argentina (-10.0Moz, 311t), Mexico (-9.6Moz, 299t) and Bolivia (-7.2Moz, 223t). Despite the disruption caused by the pandemic, mines in other countries were able to continue operating at full capacity throughout the year and output increased in Chile (+9.1Moz, 284t), India (+1.2Moz, 38t) and Australia (+1.2Moz, 37t).

Chemical Composition

Silver Ingot Specification		
Ingot Weight	:	30 Kg
Length (Top)	:	310 mm
Length (Bottom)	:	280 mm
Width (Top)	:	150 mm
Width (Bottom)	:	120 mm
Height	:	75 mm

LBMA Accredited Good Delivery Bars.

Component	Composition
Silver (Ag)	99.99 % Min
Antimony (Sb)	0.0020 % Max
Lead (Pb)	0.0020 % Max
Copper (Cu)	0.0020 % Max
Iron (Fe)	0.0020 % Max
Bismuth (Bi)	0.0015 % Max
Zinc (Zn)	0.0020 % Max
Selenium (Se)	0.0001 % Max
Telurium (Te)	0.0002 % Max
Calcium (Ca)	0.0001 % Max
Magnesium (Mg)	0.0001 % Max
Silicon (Si)	0.0001 % Max
Aluminium (Al)	0.0001 % Max
Arsenic (As)	0.0001 % Max
Cadmium (Cd)	0.0001 % Max
Chromium (Cr)	0.0001 % Max
Cobalt (Co)	0.0001 % Max
Nickel (ni)	0.0001 % Max
Gold (Au)	0.0001 % Max
Platinium (Pt)	0.0001 % Max
Palladium (Pd)	0.0001 % Max
Tin (Sn)	0.0001 % Max
Indium (In)	0.0001 % Max
Manganese (Mn)	0.0001 % Max

Figure 45: HZL Silver Specifications

After rising for two years, global silver demand weakened by 10% in 2020 to 896.1Moz (27,872t) as the impressive gains in physical investment were more than offset by heavy losses in jewellery and silverware. After falling just short of record levels in 2019, industrial fabrication fell 5% last year to a five-year low of 486.8Moz (15,142t). Unsurprisingly, this was overwhelmingly due to the impact of the COVID-19 pandemic on economic activity and, in turn, many silver end-users. Regional performances diverged, with Europe suffering a notable 8% decline, while North America rose by 2%, chiefly through higher demand in such areas as silver powder for photovoltaic (PV) ends. Demand in East Asia also fell overall, although performances were very mixed at the country-level; losses were seen in China, but Japan and Taiwan enjoyed gains.

On a sectoral basis, electronics & electrical demand fell a modest 4% as gains for PV offset losses elsewhere. Other industrial offtake in turn fell 7% as a strong showing for EO catalysts could only partially counter India's heavy losses in this segment. In general, thrifting and substitution had a limited impact on silver use as the price was insufficiently high for long enough to trigger interest and as many areas present little room for further savings.

Strong growth in mine production this year is expected to be followed by continued growth in the medium term. This will be driven by increased output from a number of major operating mines alongside new projects, with a significant contribution coming from primary silver operations in Mexico.

14.4.3 Price

Figure 46: 5-Year Silver Price

(Source – Trading Economics)

In the period 2015 to 2020, the price varied around an average of approximately US$16.5/oz. During the world pandemic, silver offered a haven for storing wealth which is reflected in the average price shooting up to an average above US$24/oz. With the acceptance that the pandemic was over in mid-July 2022, the price is starting to return to earlier levels and may stabilise near to the pre-2020 levels.

15 Environmental Studies, Permitting and Social or Community Impact

15.1 Introduction

The knowledge of present environment of the core and buffer zone of the existing mining area is important to assess the impact of various project activities on environment. The knowledge of present-day environment is also helpful in planning management of environment and planning of mitigation measures. To assess the composite baseline of mine and processing facilities related to the environmental quality of the area, field assessment has been conducted considering following components of the environment, viz. land, meteorology, air, noise, water, soil, biological and socio-economic. The relevant information and data (both primary and secondary) were collected in core as well as buffer zone (10 km distance from the Mine Lease boundary) in accordance with the guidelines of MoEF&CC for undertaking EIA Studies and preparation of Draft EIA/EMP reports.

15.2 Environmental Studies

The projects should not cause any significant impact on the environment of the area, as adequate preventive measures have been adopted to contain various pollutants generated due to the proposed current and proposed expansion projects within permissible limits. Development of Greenbelt / Plantation around the mining lease will minimize the environment pollution and improve the overall aesthetic beauty.

Environmental Monitoring Programme has been and will be continued for various environmental components as per conditions stipulated in Environmental Clearance Letters issued by MoEFCC & Consent to Operate issued by SPCB. Six monthly compliance reports will be submitted every year to Regional Office by 1st of June & 1st of December. Quarterly compliance Report for conditions stipulated in Consent to Operate will be submitted to SPCB on regular basis.

15.2.1 Land Use

Land use studies, delineating forest area, agricultural land, grazing land, wildlife sanctuary, national park, migratory routes of fauna, water bodies, human settlements and other ecological features were completed. Land use plans of mine lease areas were prepared to encompass preoperational, operational and post operational phases.

The Zawar group of mines is located within hilly area & marked by rugged and hilly terrain, dominated by steeply dipping outcrops and small valleys carved by the networks of ephemeral streamlets and streams. The drainage pattern is subdendretic to dendritic. The general slope of the area is from west to east and northwest to southwest. In the northern and western part of the area, there are some high peaks of the hills. The southeastern part has comparatively lower elevation having lowest elevation i.e., at Khakhadara. The major part of these hilly areas is under forest cover.

Total lease area is 3620 hectares lease area, and the breakup of lease area is as follows:

Table 66: Land use Patterns

Description	Mining Lease (Ha)
Mine Area	478.89
Forest Area	1537.91
Forest scrub outside forest	59.84
Agriculture	155.35
Built-up area	99.75
Waste Land	1050.2
Shadow	128.94
Water Bodies	90.97
River Sand	18.15
Total	3620.00

The existing land in use and proposed land use in the acquired area within the mining lease is shown in table below:

Table 67: Current and end of life land use

Particulars	Present Position of area (Ha)	End of Life (Ha)
Mining Activity		
Mining	36.63	46.36
Roads	10.86	10.86
Process Plant	9.46	23.82
Infrastructure & Workshops	62.68	66.88
Townships	37.95	38.95
Plantation	170.85	190.85
etc		
Tailing dam	107.63	147.52
Waste dumpsite	10.57	0.5
Mineral Storage	3.95	4.73
CPP	19.9	19.9
Community Development	8.71	8.71
Remaining Land	3140.81	3060.92
Total Area	**3620.00**	**3620.00**

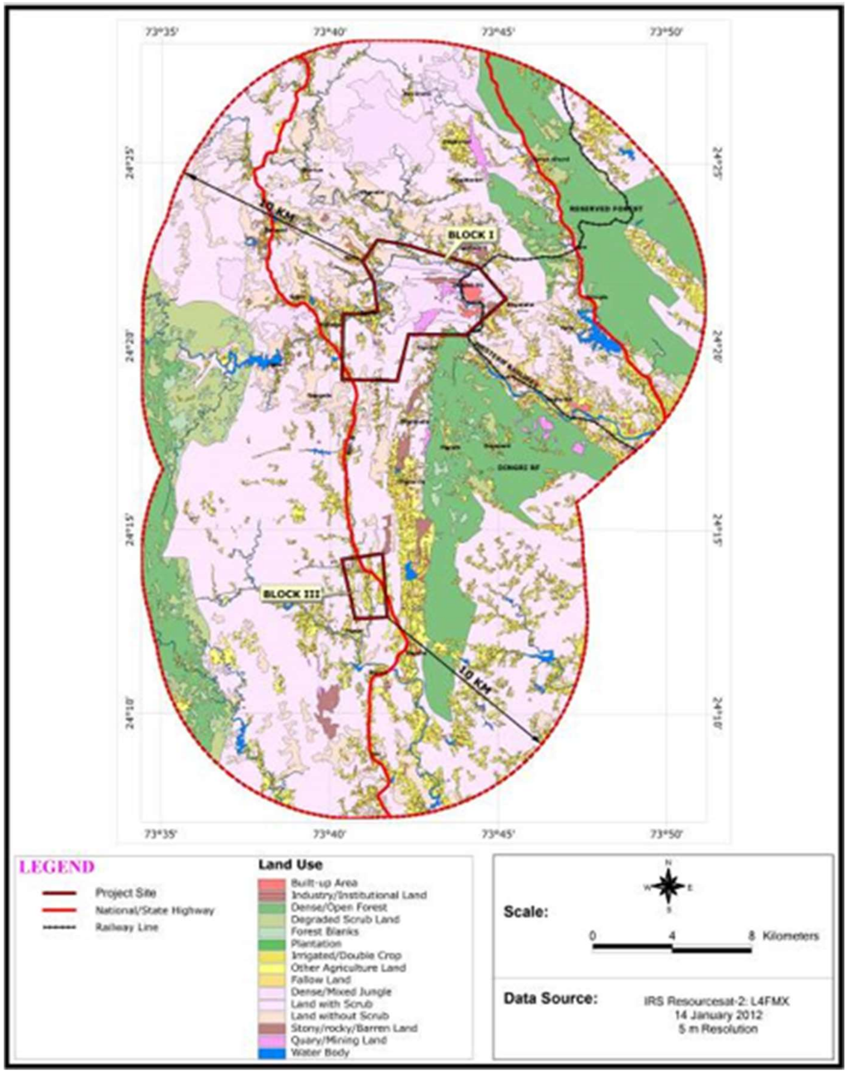


Figure 47: Land Use Pattern based on Satellite Imagery

At the end of 2020-21, the damage to the landscape in the form of infrastructure development etc., No additional land is proposed to be degraded. As the mining process is underground mining, this will not have any impact on surface area of leasehold.

The land use for mining lease area at the end of 2020-21 is given below:

The study area mainly comprises of forest land (54.63 %) and open scrub Land (35.03 %). Vegetation and plantation spreads over 4.54 % and agriculture land (1.73 %) of total study area. Built up area is represented by human settlements (0.74 %). Due to the mining project, increased human settlements are concentrated near the mine lease area as employment will be generated. There is a possibility of increase in transportation and population in the nearby villages that will result in change in the present land use and land cover. Water bodies in the study area comprise of the Tidi Dam etc. (0.72 %) and River/Nala (1.04 %). Mining areas comprise of active quarries and mined out area (1.08%) and a tailing storage facility (0.09%).

15.2.2 Climatology

The climate of the Northern India is generally dry and healthy, and the seasons are the same as those generally in the Deccan. The summer season starts during the middle of February and - continues up to the first week of June. Summer is followed by southwest monsoon which last until the end of September. October and November are the post-monsoon months. December is the coldest month with mean daily maximum and minimum temperatures being 24^0C and 10^0C respectively. During peak summer, temperature shoots up to 44.6^0C. Relative humidity varies from 25% in summer to 82% in winter (Census 2011). Udaipur district lies on the southern slope of the Aravalli Range of Rajasthan and has semi-arid climate, which prevails for most part of the year.
The mean daily maximum temperature is 39°C during May and mean daily minimum temperature is 10.8°C during December. The annual mean temperature is 24.1°C. A review of rainfall pattern during last 10 years (2010-2020) of District Udaipur reveals that the rainfall in the area is highly erratic. The annual average rainfall in the region is around 805.15 mm (average of last eleven years rainfall data from 2010-2020) varying from minimum 594.07 mm in 2018 to maximum 1077.79 mm in 2019.

15.2.3 Air Quality

Ambient air quality monitoring has been carried out within the study areas to determine the baseline concentration of various air pollutants in the ambient air. The ambient air quality depends upon the emission sources, meteorological conditions, and the background concentration of specific pollutants. This helps in providing a data base for predicting impact on the surrounding area due to a project activity. It is a standard to ensure the quality of air environment is in conformity to standards of the ambient air quality during operation phase of the projects.

- The mine sites have provided mechanical ventilators for air circulation
- Wet drilling is being used to suppress the dust generation
- The trucks are being covered with tarpaulin sheets
- Dust generation during working will be minimized by adoption of dust suppression systems at working faces.

- Water spraying on haul road.
- During transportation and unloading points, water sprinkling is being/ will be done to suppress the fugitive emissions.
- The crusher and Screens houses are provided with dust extraction system with outlets
- Development of green belt within lease area & plantation within ML Area is being done.
- Regular monitoring of air quality
- On surface, blacktop paved/ concrete roads
- Deployment of mechanized vacuum road sweeper on surface roads

The underground mining project includes various mining operations involving drilling, blasting, primary crushing and beneficiation process that takes place on surface includes transportation of ore to beneficiation plant, crushing, tailings disposal and vehicular movement are the sources to air pollution. These operations result in generation of dust and thereby pose health hazards. However, adequate control measures will be provided at every stage of operation. The mining activities will be confined to underground and will have insignificant effect on air pollution on the surface.

15.2.4 Noise Pollution

As most mining activities are restricted to underground, the effect on the surrounding population is limited. Regardless, HZL has taken all necessary measures to minimise the noise effects:

- Compressors are installed in isolated building with acoustic enclosures.
- Ventilation fans are provided with silencers
- DG sets have acoustic enclosures.
- All vehicles and machineries used have noise emissions within permissible limits through regular maintenance.
- Improved design of chutes and mill liners.
- Good grindability due to soft ore.
- Regular monitoring of noise level of mining & milling equipment.
- UG HEMM are procured with latest emission standard engines.
- UG HEMMs are equipped with airconditioned cabins thereby attenuating noise level while operating the equipment.
- A green belt is developed to attenuate the noise levels

- Reducing the exposure time of workers to the higher levels of noise
- Provision of personnel protective equipment such as ear plugs, earmuffs etc.

Ambient noise levels were measured at 15 locations in and around the mine site. Noise level varies from 51.9 to 70.2 Leq dB(A) during daytime and from 42.3 to 63.5 Leq dB(A) during night-time. The highest value of noise level monitoring at day time was observed at CPP and lowest value at Village Kalipipli . At night-time, the highest value was observed in CPP and lowest value at Village Kalipipli. There is no other major source of noise pollution.

From the above study and discussions, it can be concluded that noise levels in the study area are well within the prescribed limits as prescribed by the Noise Pollution (Regulation and Control) Rules.

Since almost all the mining activities will take place below ground, except the ore crushing and transportation on the surface. The noise levels due to drilling; blasting and operation of mining equipment will be confined to underground only and attenuated due to the depth of the operation.

In summary, it can be stated that the impact on the present noise levels due to mining operations are/will be restricted to the work zone areas only. Hence, the noise levels impact due to expansion in mining operations on community is/will be insignificant.

15.2.5 Surface Water and Wetlands

The chemical analysis of surface water samples reveals that there is a variation in chemical composition of water samples from the nearby water bodies. The pH of the water bodies ranges from 7.52 to 7.9 indicating slightly alkaline in nature. The water bodies are rich in Calcium, silica, potassium, magnesium, and bicarbonates. The colour and turbidity were of permissible range and odour was found agreeable at all the locations.

- No wastewater is being/will be discharged outside the ML Area
- Water reclaimed from tailing storage facility (TSF) is pumped back for use in process. Garland drains around TSF and sumps have been constructed to channelize the rainwater. Similar arrangement shall be provided for new TSF.
- Mine water constituted by seepage of rainwater and percolating ground water into the mines is being collected in underground sumps from where it is being pumped to surface storage tanks for reuse in mining operations like drilling, dust suppression and reuse in beneficiation plant.

- The wastewater generated from domestic operations is channelized to existing Sewage Treatment Plant (450KLD) and reused in plantation after appropriate treatment.
- Oil trap system at vehicle maintenance workshops and vehicle washing facilities.
- Rainwater harvesting structure in mining lease area
- Regular monitoring of surface and ground water

Thus, it can be inferred from the above data that water quality of all the monitoring stations seems to be clean. Also, the physical quality and chemical quality is good and safe for aquatic biodiversity.
It can be concluded from the composite baseline sampling results of Mine and CPP, for groundwater that all the samples were observed to be within the permissible limits and complies to the drinking water standard (IS: 10500-2012). However, considering the scarcity of potable water in the area, HZL will assist for improving the drinking water facilities in the area under EMP/ CSR program.
With the underground mining of lead and zinc at Zawar mines, the water regime is not likely to be affected, disturbed or polluted. The surface and ground water resources of the area, which are being utilized for drinking and irrigation purposes will be continued to be exploited despite underground mining operations and the present hydrological, hydrogeological and hydro geochemical setting of the core and buffer zone will not be affected.

15.2.6 Groundwater

Ground water samples were collected from the available water resources around the mine site. The samples were collected and tested from different sites.
The physico-chemical quality of groundwater was compared with drinking water standard (IS:10500-2012). All the groundwater samples showed good ground water quality. The pH of the water samples ranged from 7.38 to 8.06 indicating slightly alkaline in nature; and maximum pH was recorded at Zawar village. The colour and turbidity were found to be BDL, and odour and taste were agreeable at all sampling locations. The observed value of parameter varies from: total hardness (260.68 to 465.87 mg/l), alkalinity (206.56 to 377.32 mg/l), total dissolved solids (556 to 964 mg/l). However, maximum hardness and dissolved solids were found in the samples of Dewala and Kalipipli village respectively. The presence of calcium and magnesium ions in the water indicates the high values of above-mentioned parameters.
The concentration of chloride was found to be (102.54 to 201.68 mg/l) and sulphate was (42.87 to 143.87 mg/l). The concentrations of other micro and macro nutrients were also at low level i.e.

calcium (34.88 to 114.74 mg/l), magnesium (34 to 68.1 mg/l), and iron (0.26 to 12.03 mg/l). Thus, it can be concluded from the composite baseline sampling results of mining and processing, for groundwater that all the samples were observed to be within the permissible limits and complies to the drinking water standard (IS: 10500-2012).

However, considering the scarcity of potable water in the area, HZL will assist for improving the drinking water facilities in the area under EMP/ CSR program.

15.2.7 Soil

The information on soil quality has been arrived by collection and analysis of soil samples from representative locations. To assess the base line characteristics of soil profile of the mine lease area representing project and nearby areas, the samples were analysed for key and chemical parameters. The sampling locations were finalized with the following considerations:

- To enable information on baseline characteristics and,
- To determine the impact of mining activities on soil characteristics.
- To determine the type of plantation

Representative soil samples were collected from different specified locations within the study area of the mine site. Standard operating procedures were followed for the sampling and analysis of physico-chemical parameters.

The soil samples mostly exhibit blackish brown and brownish colour at all the sampled villages. The organic matter present in the soil observed to be appropriate (0.86% to 1.29 %) from the plant growth. The textures of the soil samples were sandy loam and sandy clay loam at. All soil samples were neutral in nature except for the soil in Village Dewala which is slightly alkaline in nature. The pH range from 7.17 to 8.03, which is an optimal range for most of the plants to thrive and grow. Six essential nutrients required for an ideal plant growth are nitrogen, phosphorus, potassium, magnesium, sulphur and calcium. All the essential nutrients were observed to be present in a higher amount than the other micro-nutrient and macro nutrient such as nitrogen (151.62 to 249.42 kg/ha), phosphorous (31.73 to 54.6 kg/ha), potassium (104.06 to 278.67 kg/ha), magnesium (209.75 to 364.05 mg/kg), calcium (1021.81 to 2070.56 mg/kg). Higher calcium values in the soil sample are due to the presence of alkaline soil in nature within the area, thus would positively affect the plant growth. These results indicates that the soils quality within the study area is of a good quality and contains sufficient macronutrients which is vital for healthy plant growth

15.2.8 Biological Environment

The biological environment includes the habitat and natural surroundings of all living organism species of the particular area. The biological study was undertaken as a part of the EIA study to understand the present status of ecosystem prevailing in the study area and to study the floristic and faunal diversity of the terrestrial and aquatic environment of the study area within the 10 km radius of the mine site. Studies on various aspects of ecosystem play an important role in identifying sensitive issues for undertaking appropriate action to mitigate the impact, if required.

Floral Diversity: As per the field survey and List of Flora; no endemic species of flora have been observed. Total of 57 trees, 39 shrubs, 91 herbs, 20 species of grass and n0 species of climbers have been recorded in the study area based on primary observation as well as based on information collected from the secondary data. Out of all the floral species found in the study area 37 are agricultural crops. As per the field survey and List of Flora by ENVIS, MoEFCC; no endemic, endangered and rare species of flora have been observed under threatened status in the study area.

Faunal Diversity: Among fauna, 18 species of mammals, 10 species of reptiles and 7 amphibians and 7 species of Butterfly and Arthropods were recorded from the study area. Among avifauna, 79 species were recorded in the study area. No National Park, Sanctuary, Biosphere Reserve, Migratory Corridor of wild animals exists within 10 km radius study area. Among aquatic fauna, 8 species of fishes, 1 amphibia, 3 species of insects and 6 birds were recorded in the study area. Along with these, 52 different species of phytoplankton and zooplankton have been recorded.

No adverse impact is envisaged on the existing flora, as there will be no deforestation by mining operation.

There are herbs and shrubs and few scattered trees within ML area. Greenbelt/plantation area shall be developed in 7.5 m safety barrier all around the ML and within mine lease area. The greenbelt and plantation development will eventually attract micro fauna, birds etc. in the area which will also have positive impact. Support will be taken from local forest and agricultural departments in selection of species of plants so that green coverage could improve fast.

No existence of National Parks, Sanctuaries, Biosphere Reserves, Wildlife Corridors, Tiger/Elephant reserves (existing as well as proposed) within 10 km radius from mines. Seven schedule - I species (02 species of mammals, 01 species of butterflies, 01 species of reptiles and 03 avifaunal species) were recorded in the study area during field survey. List of flora and faunal species and conservation plan has been authenticated. During Field Survey, no endemic, rare, endangered and threatened species of flora are recorded under threatened status in the study area. The revised Wildlife Conservation Plan has been submitted for Schedule I species of Zawar Group of Mines to Deputy Conservator of Forest (Wildlife) Udaipur dated 03.07.2020.

15.3 Requirements and Plans for Waste and Tailings Disposal, Site Monitoring, and Water Management

15.3.1 Waste and Tailings Disposal

The currently operating Zawar Mine TSF is located close to and to the east of the Baroi mine site. Two further potential areas to cater for requirements for the envisaged LoM, including provision for the possible increased throughput have been identified. These are a possible extension (39 ha for 15 Mt of tailings) adjacent to and west of the original ZWM TSF located to the south of the plant area and an area to the north of the Baroi and Zawarmala mines (45 ha for 18 Mt of tailings).

The total amount of 4.84 Mt tailings shall be generated from beneficiation plant during 2021-22:

- 4.16 Mt tailing disposal shall be accommodated in tailing dam.
- 0.68 Mt of tailing is proposed to be backfilling during the year 2021-22 into underground voids. Implementation of backfilling is subject to positive outcomes of proposed economic feasibility study.

Size of tailing dam area – 82 Ha

Present Height – up to 434 mRL (61m) wet disposal completed, 434 -454 dry stacking

Present Balance capacity for dry stacking – 3.9 Mt (As on April’21)

15.3.2 Site Monitoring

Monitoring of various environmental parameters are carried out on a regular basis to ascertain the following:

- Status of Pollution within the mine site and in its vicinity.
- Generate data for predictive or corrective purpose in respect of pollution.
- Examine the efficiency of pollution control system adopted at the site.
- To assess environmental impacts.
-

Monitoring is being carried out at the site as per the norms of CPCB. Environmental Monitoring Programme is conducted for various environmental components as per conditions stipulated in Environmental Clearance Letter issued by MoEFCC & Consent to Operate issued by SPCB. Six monthly compliance reports are submitted to Regional Office by 1st of June & 1st of December. Quarterly compliance Report for conditions stipulated in Consent to Operate are submitted to SPCB on regular basis.

Documentation of surveillance activities will be maintained by the EoR (Engineer of Record) as described and will include recording of:

- Routine visual observations (departures from normal conditions);
- Instrumentation monitoring and testing;
- Analyses and evaluations; and
- Reviews.

Documentation will include, as a minimum, the following:

- Weekly routine inspection log;
- Monthly care and maintenance monitoring report;
- Monthly surveillance network monitoring report;
- Annual engineering inspection reports for submission to HZL
- Comprehensive dam safety reports every 2 years.

Documentation will include a hard copy (paper) and electronic filing system for inspection reports, photographic and video records, incident reports, instrumentation readings, instrumentation plots, annual inspections and third-party reviews, so that they can be quickly retrieved for review and in case of an emergency.

EoR, Environmental Head, Mill Head, Mines manager & Unit Head collectively review collected data records from facility monitoring and assess the need for maintenance activities or response. The reporting procedures for various levels of surveillance are summarized below.

15.3.3 Water Management

The majority of the water make up requirement is supplied from underground dewatering with additional water available from a nearby dam located around 12 km from the plant. This dam is owned by HZL. Underground water is not treated prior to use in the plant. Historically, plant tailings were not thickened, and all water was returned from the dam. Once the new tailings thickener is operational water will be recirculated from the thickener overflow with a smaller amount returned from the tailings dam for reuse on the plant. Net water consumption is reported to be around 0.5 m^3/t and water supply is reported not to be a problem especially with the large water storage dam available.

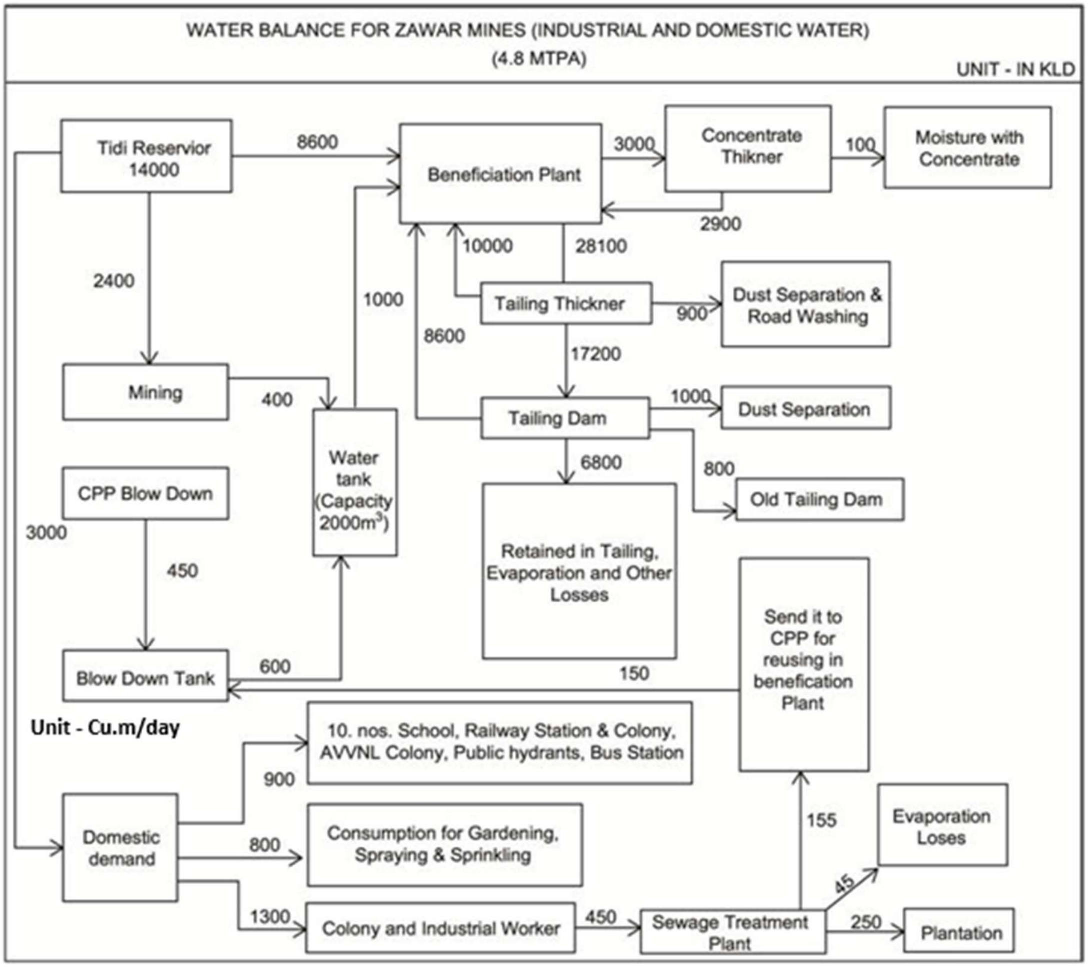


Figure 48: Water Balance - Zawar Mines - 4.8Mtpa

15.4 Required Permits and Status

The mining lease period of Zawar group of Mines over an area of 3620 ha has been extended until 31.03.2030 with letter no. khA/udai/cc-3/pr/sarada/323/08/3856 dated 26.02.2015 from DMG and thereafter the rider agreement in this regard has been executed with the state government on 06.07.2016. As on 01.04.2020, the reserves were less due to which Zawar group of Mines could not have sustained for next 5 years with current production rate. This year HZL has increased reserves for sustaining Zawar group of Mins with maximum 5.9 million tonnes up to 2024-25.

The presented Mining Plan along with Progressive Mine Closure Plan pertains for Zawar Mines lease (ML 3/89) of M/s Hindustan Zinc Limited situated near village Zawar, Tehsil Sarada, District Udaipur, Rajasthan.

M/s Hindustan Zinc Ltd. has granted Zawar Mines lease hold area of 3620 ha, which is divided in two blocks Block 1 (3172 Ha) and Block 3 (448 Ha) for systematic & scientific development of deposit. It has four operating mines namely Mochia, Balaria, Zawarmala and Baroi falls in Block 1 and Bara deposit falls in Block 3 requires further exploration before starting of mining activity.

Zawar Mining Lease was initially granted from 01.04.1950 for 20 years for 5178 Ha area, which got subsequently renewed twice. The first renewal granted on 13.03.1973 from 01.04.1970 up to 31.03.1990 and Second renewal granted on 20.10.1992 from 30.03.1990 (5178 Ha area) with conditional validity up to 05.01.2000, which got extended up to 29.03.2010 after forest area diversion of 1537.91 Ha land and thus total leasehold area reduced to 3620 Ha. The application for Third renewal was submitted to Dept. of Mines & Geology on 25th Nov. 2008 within the statutory timeline.

Environment clearance for 4.8 Mtpa ore production and beneficiation was granted vide letter No. J-11015/259/2012-IA. II(M), Dated 16.10.2020 by MoEF, New Delhi.

During Second renewal (30.03.1990 – 29.03.2010) of mining lease, permission for mining into forest land with diversion of 1537.91 Ha of land for underground use and 114.94 Ha of land for surface use were granted by Govt. of India in the year 1998. This permission was co-terminus with the lease period up to 29.03.2010. Along with 3rd lease renewal, the proposal for forest land use was submitted to Govt. of India and final approval was received vide MoEF letter dated 23.01.2015

Instead of Third renewal of lease period, The Dept. of Mines & Geology, Govt. of Rajasthan issued a fresh letter extending the period of lease validity till 31.03.2030 as per Section 8A(5) of MMDR (Amendment) Act, 2015 vide letter no. [kv@mn;@lhlh&3@iz@ljkM+k@323@08@3856 dated 26.02.2015 considering Zawar Group of Mines as “CAPTIVE”. The ongoing process of 3rd renewal (30.03.2010 to 29.03.2030) were made null void. In line with above letter, a rider agreement has been made with DMG on 06.07.2016 and thereby accordingly Mining Plan being submitted.

The mining lease period of Zawar group of Mines over an area of 3620 ha has been extended up to 31.03.2030 with letter no. khA/udai/cc-3/pr/sarada/323/08/3856 dated 26.02.2015 from DMG and thereafter the rider agreement in this regard has been executed with the state government on 06.07.2016.. As on 01.04.2020, the reserves were less due to which Zawar group of Mines could not have sustained for next 5 years with current production rate. This year we have increased reserves for sustaining Zawar group of Mine’s with maximum 5.9 million tonnes up to 2024-25.

15.5 Community Engagement

For the Zawar Area, 21 villages/ward comes under the primary zone (0 – 3 km radius from plant site) with as much as 6,444 houses resides with a total population of over 32,876 people. Due to shorter distance from mine site, it gives people living in here fair opportunity to get enrolled at project site and avail possible benefits (less transport cost/time saving) than to people living in other zones.

The primary survey conducted in these villages and census information suggests that availability of basic needs such as provision to food, clothes, shelter, employment opportunities, transport connectivity, education availability, health infrastructure, cooking fuel and natural resource availability is good.

The Socio – economic study of the area where lead zinc mine is located in Udaipur district of Rajasthan gives a clear picture of how it a favourable place in bringing development. It cites demographic patterns (viz. gender and sex ratio, child sex ratio, family size,), present infrastructures, provision to basic amenities, educational facilities, occupational structure, health and hygiene, transport facilities, various social protection schemes running by central and state governmental schemes for welfare of locals and vulnerable groups. Thus, this whole study of socio–economic concludes that mine project is suitable for sound socio economic development and with time it will only keep on positively evolving the region and its inhabitants thereby meeting end needs.

The project may trigger negative health impacts through increased dust &gases which might introduce respiratory illness for the workers involved in the underground mining operations. Due to the labour intensity of the mining sector, the project attracts the more able-bodied persons from the community which in turn lead to low labour availability in other sectors of the economy including agriculture. However, the activities of the mine produces some improvements in the socio - economic levels of the study area.

Contractual workers should increase in coming years with enhancement of mine development & other activities at Zawar Mines. The project in its present shape has been a major avenue to the local population around 10 kms periphery. Around 50% of the regular employees of the company are from local population whereas in case of contractual employees the figure stands at 85% of the total.

The local community benefits from the training programmes that are instituted by HZL to enable the community labour force to work for their livelihood/Self-growth.

Villages in the Zawar Mines region have better public utility status than villages situated further away. Improvement in facilities is a result of overall economic development of the area. Some of the villages in core areas also receive piped water supply from HZL will increase income of local community and therefore improve the overall standard of living in the area.

15.6 Mine Closure

Mine rehabilitation, based on the information provided to ABMC, there is no standalone mine closure plan for the Zawar group of mines. Rather, mine restoration is based on a plan for the next 3 years on what should be done to restore the surface to prior mining times. These activities are focussed on two aspects – planting trees on surface and on backfilling old working areas. This is seen in the following Table

Table 68: Tree Planting on mine Lease Area

Items	Details	Proposed	Remarks
Dump management	Area afforested (ha)	-	
	No of saplings planted	-	
	Cumulative no of plants		
	Cost including watch and care during the year		
Management of worked out benches	Area available for rehabilitation (ha)	-	
	Afforestation done(ha)		
	No of saplings planted in the year		
	Cumulative no of plants		
	Any other method of rehabilitation (specify)		
	Cost including watch and care during the year		
Reclamation and Rehabilitation by backfilling	Void available for Backfilling (L x B x D) pit wise /stope wise (Cu.m)	Mochia -211000 Balaria -13300 Zawarmala-176700 Baroi -0 Total Zawar - 401400Cu.m	Void generation due to stoping during RY
	Void filled by waste /tailings (Cu.m)	Mochia -687100 Balaria -524800 Zawarmala -348900 Baroi -289500 Total Zawar - 1860300 Cu.m	Quantity of taling to be used for backfilling during RY
	Afforestation on the backfilled area	-	
	Rehabilitation by making water reservoir	-	
	Any other means (specify)	-	
Rehabilitation of waste land within lease	Area available (ha)	5 Ha	
	Area rehabilitated		
	Method of rehabilitation - Plantation (No. of saplings)	5000	
Others (specify)			

15.7 Adequacy of Plans

Even though the mines in the HZL Group are geographically separate and each has different structural, resource, grades, mining, water management problems, etc to be resolved, the Group is operating as a unit. Individual mines appear to operate well in terms of understanding their mine's unique problems and solving them, but there are many similarities such as all being underground, with limited influence on the environment such as back filling and zero water discharged to the environment.

Many of these issues are probably guided by the Group. In-house experienced personnel should be easily transferred should a problem occur in one of the mines. Within the Group there must be guiding principles and plans in terms of all activities such as environment management and mine closure procedures. In our opinion adequate plans are in action after a long time of experience of similar mining management within the Group.

16 Capital and Operating Costs

16.1 Operating Cost Estimate

ABGM did not undertake any techno-economic assessments on the mining costs, processing costs and fixed royalties. The following operating cost estimates was received from HZL that is used in their financial and budget planning for FY2022 – 2030.

Table 69: Summary of Operating Costs (source HZL)

Particulars	UoM	Yr 2022	Yr2023	Yr 2024	Yr 2025	Yr 2026	Yr 2027	Yr 2028	Yr 2029	Yr 2030
Mining Cost	$/MT Ore	23.0	24.2	25.4	26.7	28.0	29.4	30.9	32.4	34.0
Processing Costs	$/MT Ore	6.5	6.8	7.2	7.5	7.9	8.3	8.7	9.2	9.6
Development	$/MT Ore	14	15	16	16	17	18	19	20	21
Smelter Cost										
Zn Metal	$/MT Metal	454	454	454	454	454	454	454	454	454
Lead Metal	$/MT Metal	585	585	585	585	585	585	585	585	585
Silver Metal	$/MT Metal	24	24	24	24	24	24	24	24	24
Overall Cost										
Mining Cost	$ Mn	219	278	331	351	249	132	117	123	129
Smelter Cost	$ Mn	88	107	121	122	83	42	35	35	35
Royalty Cost	$ Mn	66	80	91	91	62	31	26	26	26

16.2 Capital Cost Estimate

No capital cost estimates was evaluated in the limited timeframe of this technical review.

17 Economic Analysis

ABGM did not undertake any techno-economic assessments on the reserves and only evaluated the mining cost and applied the high level mining cost, processing costs and fixed royalties to determine a nominal cashflow with some limited sensitivities.

17.1 Model Parameters

Table 70: Costing and Financial Inputs per annum (supplied by HZL)

Assumption	Yr 2022	Yr2023	Yr 2024	Yr 2025	Yr 2026	Yr 2027	Yr 2028	Yr 2029	Yr 2030
Grade									
Zn	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Pb	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Silver	30	30	30	30	30	30	30	30	30
Recovery-Mill									
Zn	92	92	92	92	92	92	92	92	92
Pb	89	89	89	89	89	89	89	89	89
Silver	74	74	74	74	74	74	74	74	74
Recovery-Smelter									
Zn	96	96	96	96	96	96	96	96	96
Pb	98	98	98	98	98	98	98	98	98
Silver	100	100	100	100	100	100	100	100	100
Impact on Cost									
Mining	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Zn Premium	180	180	180	180	180	180	180	180	180
Pb Premium	150	150	150	150	150	150	150	150	150
Ag Premium	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4

17.2 Taxes, Royalties, Depreciation

The normal government taxes have been applied to the models indicated below. The exact percentages were not disclosed by HZL. The royalties applied in the models are indicated in the start of document but can be seen below.

- The Royalty for Lead is 14.5% of London Metal Exchange lead metal price chargeable on the contained lead metal in the concentrate produced.
- The Royalty for Zinc is 10% of London Metal Exchange Zinc metal price on ad valorem basis chargeable on contained zinc metal in the concentrate produced.

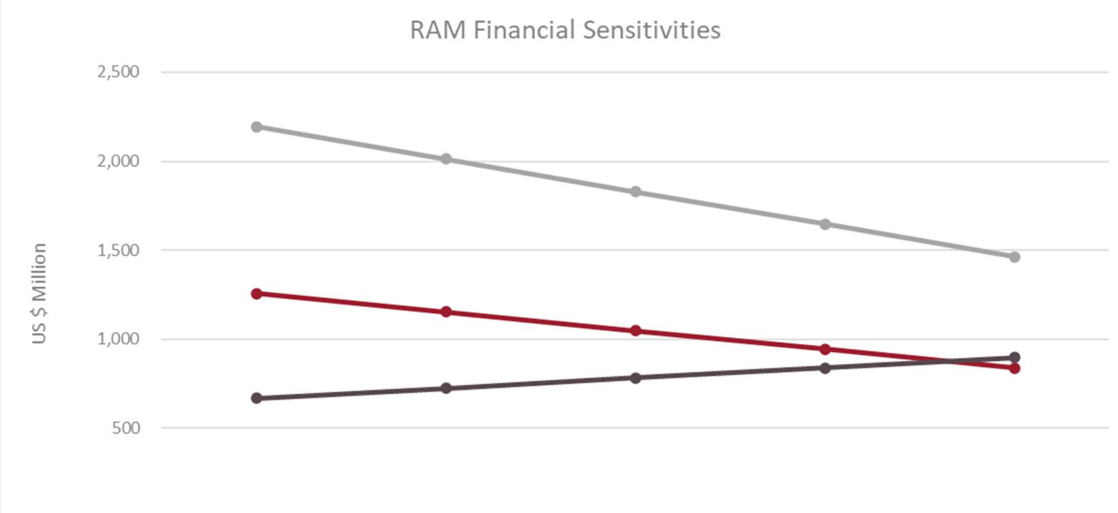
17.3 Cashflow Forecasts and Annual Production Forecasts

Table 71: Financial model outcome (2023 - 2030)

Particulars	UoM	Yr 2022	Yr2023	Yr 2024	Yr 2025	Yr 2026	Yr 2027	Yr 2028	Yr 2029	Yr 2030
Ore production	MT	5,000,000	6,050,000	6,868,000	6,924,000	4,688,000	2,369,000	2,000,000	2,000,000	2,000,000
Zn Metal in Concentrate	MT	114,974	139,119	157,929	159,216	107,800	54,475	45,990	45,990	45,990
Lead Metal in Concentrate	MT	66,775	80,798	91,722	92,470	62,608	31,638	26,710	26,710	26,710
Silver Metal in Concentrate	KG	111	134	152	153	104	52	44	44	44
Zn Metal	MT	110,557	133,774	151,862	153,100	103,659	52,382	44,223	44,223	44,223
Lead Metal	MT	65,154	78,837	89,496	90,226	61,089	30,870	26,062	26,062	26,062
Silver Metal	KG	110	133	152	153	103	52	44	44	44
Mining Cost	$/MT Ore	23	24	25	27	28	29	31	32	34
Processing Costs	$/MT Ore	7	7	7	8	8	8	9	9	10
Development	$/MT Ore	14	15	16	16	17	18	19	20	21
Smelter Cost										
Zn Metal	$/MT Metal	454	454	454	454	454	454	454	454	454
Lead Metal	$/MT Metal	585	585	585	585	585	585	585	585	585
Silver Metal	$/MT Metal	24	24	24	24	24	24	24	24	24
Royalty										
Zinc	$/MT Metal	364	364	364	364	364	364	364	364	364
Lead	$/MT Metal	394	394	394	394	394	394	394	394	394
Silver	$/MT Metal	60	60	60	60	60	60	60	60	60
Zn LME	$/MT	2,759	2,759	2,759	2,759	2,759	2,759	2,759	2,759	2,759
Pb LME	$/MT	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057
Ag LBMA	$/Troz	21.24	21.24	21.24	21.24	21.24	21.24	21.24	21.24	21.24
Ex Rate	Rs/USD	76.65	76.65	76.65	76.65	76.65	76.65	76.65	76.65	76.65
Revenues										
Zn	$ Mn	325	393	446	450	305	154	130	130	130
Pb	$ Mn	144	174	198	199	135	68	58	58	58
Ag	$ Mn	84	101	115	116	79	40	34	34	34
Mining Cost	$ Mn	219	278	331	351	249	132	117	123	129
Smelter Cost	$ Mn	88	107	121	122	83	42	35	35	35
Royalty Cost	$ Mn	66	80	91	91	62	31	26	26	26
Net Cashflow	**$ Mn**	**180**	**204**	**216**	**201**	**124**	**56**	**42**	**36**	**30**

17.4 Sensitivity Analysis

A high level sensitivity analysis is illustrated below that indicates the ZAW mining operations is in good position with up to 20% variation illustrate and overall positive financial outcome.



	20%	10%	100%	-10%	-20%
Cashflow	1,257	1,152	1,048	943	838
Cost	668	725	782	839	895
Revenue	2,195	2,012	1,829	1,646	1,463

Figure 49: ZAM Financial Sensitivity Analysis (unit: Million US $)

18 Adjacent Properties

The Zawar Mining Complex comprises 4 separate operations that share common infrastructure and they are considered adjacent mines. However, there are no other adjacent mining operation outside the complex.

19 Other Relevant Data and Information

There is an abundance of information and other data that was not fully reviewed by ABGM during this review process as there was not enough time to conduct thorough investigation in all the data sets and documents. However, the key aspects were addressed as far as possible to ensure the relevant data and information required for this technical review was addressed.

20 Interpretation and Conclusions

20.1 Results

The results of the technical review indicate that the property contains a Mineral Resource, and a significant portion of that Mineral Resource converts to a Mineral Reserve. The project / operation has a positive economic outcome given the data, parameters and estimates outlined in the TRS. Due to the short time allocated to conduct this review.

ABGM is satisfied that the mine operation is conducting the required annual statutory work and reviews and submits to the IBM (Indian Bureau of Mines). The mine is compliant in order to develop the data, scrutinize and report on information for the development of Mineral Resources and Reserves in conjunction with their current consultancy professionals.

20.2 Significant Risks

No significant risks was observed during the site visits and neither were any picked up in the data and information provided by HZL.

20.3 Significant Opportunities

No significant opportunities was observed during the site visits and neither were any picked up in the data and information provided by HZL. However some suggestions will be listed in the consolidated report.

21 Recommendations

21.1.1 Pricing assumptions

Comparing the market research and the current trend of commodity pricing. The assumptions used by HZL seem to be on the higher side to establish the cut-off grades. However, running the sensitivities, all the operations seem to be well established and not sensitive to volatile changes. HZL used the 10 year pricing average in their estimates, the three year LME forecast average seems to be higher than the last 3 year average.

21.1.2 Environmental, Social Studies

Where information is available, environmental studies are done to an acceptable level for the Indian authorities. In some cases exemplary work is being done, beyond what is strictly necessary. Sites are monitored on strict schedules and the regular submission of updated reports are sufficient for the permits to be renewed again. Standardisation of programmes and procedures is recommended for all operations as this will prevent some areas of not receiving the correct attention. Interaction with and contributions to the local staff and communities appears to be positive with the establishing of medical centres and schools.

21.1.3 Closure Plans

Mine closure plans are not always easy to see in the provided documents, but the plans appear to be well thought out and implemented. As the mining activities are mostly underground, the effect on the environment is limited to the dust and noise generated due to ore transport and the storage of tailings, a large portion of which is used for backfilling mined stopes.

21.1.4 Geotechnical Drill Core Logging

The mines need to continue its practise with respect to core logging. Recommend more detailed geotechnical logging and recording of structures.

21.1.5 Sampling Transportation

Even though no information was provided around this practise, the site inspections proved that core, as well as samples from core, are transported in solid, closed and locked metal containers. Logging, tagging and security of the custody chain for samples are tracked in acQuire database, with unique barcodes and numbers. However it is suggested that the procedures followed need to be documented and recorded better.

21.1.6 Independent Lab Analysis

It is recommended that regular pulp duplicates are submitted an independent laboratory to be analysed as umpire samples.

21.1.7 Bulk Density Data

While bulk density data has been reconciled with production data, independent bulk density analyses should be undertaken at an independent laboratory during the exploration phase to avoid errors.

References

- 31161 HZL Audit 2021_Report_Finalr

Environment	2022/06/29 09:53	File folder	
Filling Report	2022/06/29 09:50	File folder	
Geotech	2022/06/29 09:40	File folder	
LOM Report	2022/06/29 09:42	File folder	
Mettallurgical Report	2022/06/29 09:42	File folder	
Mining Plan	2022/07/21 23:10	File folder	
1_Modified_Mine_Plan__Final_A_final_21june_202122_t...	2022/07/14 13:57	Microsoft Word Docum...	5,027 KB
RR22_LoM_Schedule_0804.xlsx	2022/06/29 09:23	Microsoft Excel Workshe...	20 KB
Scan_copy_of_Approved_Mining_Plan_2021-22_to_202...	2022/07/14 13:57	Adobe Acrobat Docume...	91,859 KB

Figure 50: Files & Folders List - HZL Data and Information Pack – ZAW

_BAL_22_SRKCLASS	2022/06/21 10:43	File folder
_BAR_22_SRKCLASS	2022/06/21 10:44	File folder
_MOC_22_SRKCLASS	2022/06/21 10:44	File folder
_ZMA_22_SRKCLASS	2022/06/21 10:45	File folder

Figure 51: Data Pack (Folders per Mine) - Resource to Reserve Estimation (DataMine Files)

_combmod_log.txt	2022/04/09 14:31	Text Document	25 KB
BAL_BMAGOK22.dm	2022/03/15 23:20	DM File	1,127,956 KB
BAL_BMAGOK22CD.dm	2022/04/03 13:40	DM File	2,156,548 KB
bal_bmagok22cdcl.dm	2022/04/09 15:13	DM File	2,393,212 KB
bal_bmagok22cdcl_r.csv	2022/04/09 15:15	Microsoft Excel Comma...	6 KB
bal_bmagok22cdcl_r.dm	2022/04/09 15:15	DM File	12 KB
BAL_CLASS_RR22_V4.mac	2022/04/09 13:46	MAC File	21 KB
BAL_CP22_A25v2_pt.dm	2022/04/07 23:06	DM File	356 KB
BAL_CP22_A25v2_tr.dm	2022/04/07 23:06	DM File	1,892 KB
BAL_CP22_B25v2_pt.dm	2022/04/07 23:06	DM File	340 KB
BAL_CP22_B25v2_tr.dm	2022/04/07 23:06	DM File	1,900 KB
BAL_OK_EST22_v8.mac	2022/03/19 16:15	MAC File	46 KB
BAL_PRI_STP22v2_pt.dm	2022/04/07 23:06	DM File	700 KB
BAL_PRI_STP22v2_tr.dm	2022/04/07 23:06	DM File	3,956 KB
BAL_RIB_STP22v2_pt.dm	2022/04/07 23:07	DM File	76 KB
BAL_RIB_STP22v2_tr.dm	2022/04/07 23:07	DM File	400 KB
BAL_RRV_CP22v2_pt.dm	2022/04/07 23:07	DM File	56 KB
BAL_RRV_CP22v2_tr.dm	2022/04/07 23:07	DM File	272 KB
BAL_RRV_STP22v2_pt.dm	2022/04/07 23:07	DM File	68 KB
BAL_RRV_STP22v2_tr.dm	2022/04/07 23:07	DM File	356 KB
BAL22.rmproj	2022/04/09 15:17	RMPROJ File	113 KB
DEP_2122ONLY_pt.dm	2022/03/19 15:10	DM File	76 KB
DEP_2122ONLY_tr.dm	2022/03/19 15:09	DM File	532 KB
Dep_UPTO2021_pt.dm	2022/03/19 14:48	DM File	48 KB
Dep_UPTO2021_tr.dm	2022/03/19 14:47	DM File	428 KB
dmstusub.dat	2022/04/03 13:34	DAT	0 KB
ind_bal22v1_pt.dm	2022/03/19 13:47	DM File	8 KB
ind_bal22v1_tr.dm	2022/03/19 13:47	DM File	28 KB
meas_bal22v1_pt.dm	2022/03/19 13:48	DM File	8 KB
meas_bal22v1_tr.dm	2022/03/19 13:48	DM File	24 KB
stopecheck.csv	2022/04/09 14:38	Microsoft Excel Comma...	393 KB
stp_cog_chk.dm	2022/04/09 14:38	DM File	276 KB
t11.dm	2022/04/09 14:51	DM File	4,513,964 KB
t12.dm	2022/04/09 15:05	DM File	4,513,964 KB
TongradLog.txt	2022/04/09 15:15	Text Document	80 KB

Figure 52: Data Pack - Resource to Reserve Estimation (DataMine Files) – Balaria

_combmod_log.txt	2022/04/09 15:43	Text Document	31 KB
BAR_CLASS_RR22_v3.mac	2022/04/09 13:47	MAC File	15 KB
BAR22.rmproj	2022/04/09 16:47	RMPROJ File	113 KB
BO_BM22CDE.dm	2022/04/03 14:50	DM File	2,579,428 KB
bo_bm22cdecl.dm	2022/04/09 16:26	DM File	3,170,748 KB
bo_bm22cdecl.rar	2022/04/07 11:07	WinRAR archive	147,204 KB
bo_bm22cdecl_r.csv	2022/04/09 16:29	Microsoft Excel C...	3 KB
bo_bm22cdecl_r.dm	2022/04/09 16:29	DM File	8 KB
BO_BMAGOK22.dm	2022/02/24 19:57	DM File	1,987,804 KB
bo_cp_stp22v2_pt.dm	2022/04/07 23:10	DM File	104 KB
bo_cp_stp22v2_tr.dm	2022/04/07 23:10	DM File	576 KB
bo_depl_upto2122pt.dm	2022/02/26 00:09	DM File	248 KB
bo_depl_upto2122tr.dm	2022/02/26 00:09	DM File	6,016 KB
bo_ind22pt.dm	2022/02/24 20:53	DM File	8 KB
bo_ind22tr.dm	2022/02/24 20:53	DM File	16 KB
bo_meas22pt.dm	2022/02/24 20:52	DM File	8 KB
bo_meas22tr.dm	2022/02/25 11:45	DM File	12 KB
BO_PRI_STP22v2_pt.dm	2022/04/07 23:10	DM File	724 KB
BO_PRI_STP22v2_tr.dm	2022/04/07 23:10	DM File	4,256 KB
bo_rib_stp22v2_pt.dm	2022/04/07 23:10	DM File	100 KB
bo_rib_stp22v2_tr.dm	2022/04/07 23:10	DM File	568 KB
dmstusub.dat	2022/04/03 19:28	DAT	0 KB
stopecheck.csv	2022/04/09 15:49	Microsoft Excel C...	149 KB
stp_cog_chk.dm	2022/04/09 15:49	DM File	112 KB
TongradLog.txt	2022/04/09 16:29	Text Document	81 KB

Figure 53: Data Pack - Resource to Reserve Estimation (DataMine Files) – Boroi

_combmod_log.txt	2022/04/09 13:46	Text Document	4 KB
dmstusub.dat	2022/04/03 21:55	DAT	0 KB
stopecheck.csv	2022/04/09 13:46	Microsoft Excel Comma...	25 KB
TongradLog.txt	2022/04/09 13:48	Text Document	78 KB
ZM_BMG22.dm	2022/02/27 20:25	DM File	75,564 KB
ZM_BMG22V2CD.dm	2022/03/17 13:08	DM File	111,340 KB
zm_bmg22v2cdcl.dm	2022/04/09 13:47	DM File	139,892 KB
zm_bmg22v2cdcl_r.csv	2022/04/09 13:48	Microsoft Excel Comma...	2 KB
zm_bmg22v2cdcl_r.dm	2022/04/09 13:48	DM File	8 KB
ZMA_CLASS_RR22_v3.mac	2022/04/09 13:45	MAC File	10 KB
ZMA22_ALL_STPv2_pt.dm	2022/04/07 22:11	DM File	88 KB
ZMA22_ALL_STPv2_TR.dm	2022/04/07 22:18	DM File	280 KB
ZWA22.rmproj	2022/04/09 13:48	RMPROJ File	106 KB

Figure 54: : Data Pack - Resource to Reserve Estimation (DataMine Files) – Zawarmala

_combmod_log.txt	2022/04/09 16:59	Text Document	17 KB
dmstusub.dat	2022/04/03 22:05	DAT	0 KB
MO_BM22CDE.dm	2022/04/03 15:13	DM File	1,754,928 KB
mo_bm22cdecl.dm	2022/04/09 17:19	DM File	1,361,172 KB
mo_bm22cdecl_r.csv	2022/04/09 17:21	Microsoft Excel C...	8 KB
mo_bm22cdecl_r.dm	2022/04/09 17:21	DM File	16 KB
MO_CLASS_RR22_v3.mac	2022/04/09 13:47	MAC File	24 KB
MO_CP22_A57v2_pt.dm	2022/04/07 22:57	DM File	88 KB
MO_CP22_A57v2_tr.dm	2022/04/07 22:57	DM File	420 KB
MO_CP22_B57v2_pt.dm	2022/04/07 22:57	DM File	144 KB
MO_CP22_B57v2_tr.dm	2022/04/07 22:57	DM File	780 KB
MO_OLD_STP22v2_pt.dm	2022/04/07 22:58	DM File	24 KB
MO_OLD_STP22v2_tr.dm	2022/04/07 22:58	DM File	84 KB
MO_PRI_STP22v2_pt.dm	2022/04/07 22:58	DM File	236 KB
MO_PRI_STP22v2_tr.dm	2022/04/07 22:58	DM File	1,308 KB
MO_RIB_57A_22v2_pt.dm	2022/04/07 22:59	DM File	16 KB
MO_RIB_57A_22v2_tr.dm	2022/04/07 22:59	DM File	60 KB
MO_SEC_STP22v2_pt.dm	2022/04/07 22:59	DM File	136 KB
MO_SEC_STP22v2_tr.dm	2022/04/07 22:59	DM File	732 KB
MO_SHAFT_STP22v2_pt.dm	2022/04/07 23:00	DM File	24 KB
MO_SHAFT_STP22v2_tr.dm	2022/04/07 23:00	DM File	104 KB
MOC22.rmproj	2022/04/09 18:57	RMPROJ File	113 KB
stopecheck.csv	2022/04/09 17:03	Microsoft Excel C...	137 KB
stp_cog_chk.dm	2022/04/09 17:03	DM File	100 KB
TongradLog.txt	2022/04/09 17:21	Text Document	79 KB

Figure 55: Data Pack - Resource to Reserve Estimation (DataMine Files) – Mochia