EXECUTIVE SUMMARY

NFCA holds a Large Scale Mining License (7069HQLML) in the Chambishi Area of Kalulushi District in the Copperbelt Province of the Republic of Zambia. The license is valid for a period of 25 years starting from October 2009.

The company intends to invest about US$ US$832 million to develop and operate the South East Ore body Project to process the ore deposit to concentrate stage. The rationale of the project is to operate the South East Ore body project to increase revenues for NFCA Mining Plc and provide employment opportunities for Zambians. At construction, the project is expected to employ 500 to 1000 Zambians and at full production the project is expected to employ 5000 Zambians

NFCA commissioned MOKA Environmental Consultants of Kitwe to Conduct an Environmental Impact Assessment for its South East Ore body Project and draw its Environmental Management Plans.

The EIA Study

The EIA study was conducted and it consisted of the following phases:

- A scoping meeting;
- Development of Terms of Reference;
- A review of documents and literature related to the project and in particular NFCA proposed operations;
- Socio-economic analysis of the neighbouring settlements
- A Biophysical Baseline study
- Impact assessment of bio-physical and socio-economic environments
- Compilation of Social and Environmental Management Plans and
- Closure and Decommissioning Plans and costs

Project Activities

- The project activities planned will include the following:
- Development of construction camp
- Site clearance and preparation
- Construction Phase
- Operational Phase
- Decommissioning and Closure Phase and
- Post-closure Environmental and Social Monitoring Phase

Main Project Components

The proposed South East Ore body Project will have the following main infrastructure:

Table of Contents

- One main vertical shaft, one service shaft and two ventilation shafts
- Underground mining operation; tunnel development and extraction -Mining Methods
- Three waste rock dump
- A metallurgical processing plant
- One Tailings disposal dump

Identified Impacts and Mitigation measures

Both positive and negative impacts of the proposed South East Ore body Project were identified.

The positive impacts

The following positive impacts have been identified:

- Impacts on the local and National economy through increased income for the;
- Government and the local authorities through payment of taxes and other levies;
- Impacts on local community through creation of jobs and social welfare;
- Business opportunities to local suppliers and contractors and its multiplier effect.

The negative impacts

The proposed project is likely to have the following potential negative impacts:

- Impacts on land and soil;
- Impacts on air quality;
- Impacts on surface water;
- Impacts on ground water;
- Impacts on health and safety;
- Impacts on Public Health and Safety;
- Impacts on Land use and Ecosystem;
- Impacts on Public infrastructure;

The EIA has proposed measures to mitigate the potential negative impacts of the operations of the South East Ore body Project where they may arise.

Environmental Management and Monitoring

In order to ensure successful implementation of mitigation measures, parameter monitoring and subsequent audits, Environmental Management Plans,

Environmental Monitoring Plans and Social Management Plans have been proposed.

Closure and Decommissioning

The study also looked at what will be done to restore the disturbed land. Consequent to land restoration exercise, the land should be handed back to government after the decommissioning process. The estimated cost of closure is approximately US$4.28 million.

We trust that the development will have little effect on the natural biodiversity as most of the area to be developed is already under exotic species cultivation and that there will be positive impacts on both the local and National economies as a result of the project. We therefore recommend to the Zambia Environmental Management Agency to approve the project.

Mr Wang Chunlai

CEO – NFCA Mining Plc

Principal Members of the Impact Assessment Team Comprised of the following:

Prof. Kakoma Maseka – Environmental Scientist / Team Leader

Mr. Wilson Moono – Geologist / Geotechnical Engineer

Mr. Agabu Shane – Mining Engineer / Environmental Engineer

Dr. Fredrick Chileshe – Metallurgical Engineer

Ms. Concilia Monde – Ecologist / Flora – Fauna Specialist

Ms. Mwila Maseka – Social Scientist

Ms Maureen Mwewa – Social Scientist

Water Quality

Siltation and contamination of surface water bodies may occur due to dust generated from drill sites and access roads. Accidental spillage or leakage of oil at storage areas or at the drill site may also cause minimal groundwater contamination.

Mitigation measures

- Access tracks will be sprayed with water or molasses.
- Wet drilling technique will be employed through injection of water into the drill hole thereby minimizing dust generation at the drill rig.
- Oil and fuel storage areas will be well paved and bunded to prevent leakage to the soil.
- Drill sites will be cleaned as soon as the hole is completed to remove any spilled materials and dispose them appropriately.
- All exploration vehicles and trucks will be regularly serviced to ensure that they are in good working condition to minimize oil leakages.

Flora/Vegetation

Clearance of vegetation during the preparation of access roads and drill pads may result in moderate loss of vegetation in the area.

Mitigation measures

- Access roads will be prepared along pre-existing tracks to minimize loss of vegetation.
- Cutting of bigger trees will be avoided by restricting drill pads away from bigger trees.
- Cleared vegetation will be allowed to regenerate at the end of the project.

Fauna

There will be no significant impact on fauna in the area.

Soil

Accidental oil spillages and leakages at drill sites or oil storage facilities may lead to soil contamination.

Mitigation measures

- Oil and fuel storage areas will be well paved and bunded to prevent leakage to the soil.
- Drill sites will be cleaned as soon as the hole is completed to remove any spilled materials and dispose of them appropriately.
- All exploration vehicles and trucks will be regularly serviced to ensure that they are in good working condition to minimize oil leakages.

Safety and Health

Dust generated during RC drilling may lead to occupational exposure to the drilling crew. Dust generated during handling of samples and disposal of used sample bags

ENVIRONMENTAL COMPONENT	ENVIRONMENTAL IMPACT	NATUTURE OF IMPACT	SOURCE OF IMPACT	SIGNIFICANCE OF IMPACT	MITIGATION MEASURES
					roads
			RC Drilling		Wet drilling will be employed through injection of water into the drill hole thereby minimizing dust generation at the drill site
Noise and Vibration	Increase in ambient noise levels	Negative	Trucks and 4x4 vehicles	Moderate	All exploration vehicles will be regularly serviced to ensure that they are in good working condition; Where the access road passes close to the villages, convenient speed limits will be observed to minimize noise levels
			RC Drilling		Drilling sites are far from the villages; Workers at the drill site will be provided with the necessary Personal Protective Equipment (PPE) to protect them from the elevated noise levels
Water Quality	Siltation and contamination of surface water bodies due to dust generated from drill sites and access roads	Negative	Dust generated from access roads and drill sites	Low	Access tracks will be sprayed with water or molasses to minimize dust; Wet drilling will be employed through injection of water into the drill hole thereby minimizing dust generation at the drill site
	Possible groundwater contamination	Negative	Oil spillages and leakages at drill sites or oil	Low	Oil and fuel storage areas will be well paved

ENVIRONMENTAL COMPONENT	ENVIRONMENTAL IMPACT	NATUTURE OF IMPACT	SOURCE OF IMPACT	SIGNIFICANCE OF IMPACT	MITIGATION MEASURES
	pads preparation		and drill pads		minimize loss of vegetation; Cutting of bigger trees will be avoided by restricting drill pads away from bigger trees; Cleared vegetation will be allowed to regenerate at the end of the project;
Socio-economic	Employment opportunities for the local people	Positive	The project will require local labor throughout the life of the project	Moderate	Priority will be given to the local people for employment
	Acquisition of new skills by the local people	Positive	The project will impart new skills to the local people through training them on the job	High	Priority will be given to the local people for employment
	Increase in communicable diseases, particularly HIV and AIDS	Negative	Increase in the number of immigrants moving to the area in search of employment	High	NFCA will facilitate educational programmes on HIV and AIDS in the project area
	Improvement of social infrastructure in Chambishi	Positive	The project will lead to improvements in road infrastructure which will bring about subsequent improvements in other social infrastructure; at the moment there are no water supply boreholes in the area because it is not possible to bring drilling rigs through the bad access roads	High	
Fauna	No significant impact expected to occur				

4.0 ENVIRONMENTAL IMPACTS IDENTIFICATION, ANALYSIS, AND MITIGATION MEASURES

Geological surface exploration drilling is by and large an environmental involvement by virtue of the activity and associated activities being carriedout through partial disturbance of undisturbed land or partially disturbed land.

The southeast orebody expansion project by NFC – Africa Mining Plc is located in partially disturbed land that has to some extent re-stabilized to natural eco-system. The area under consideration is semi-inhabited; one the southern side off the Chingola-Kitwe road, the area is partially on mining surface rights and partially on a private farm which has since been acquired by NFC – Africa Mining Plc. The southern orebodies and service facilities such as shafts will be located in this area. On the northern side of the Chingola – Kitwe road (N1 orebody), the area is largely under surface mining rights and partially private. This area is currently occupied by squatter subsistence farming communities.

Environmental impacts were identified on the basis of the information obtained from the environmental baseline data that was gathered during a site visit to the project area. Other impacts were identified during stakeholder discussions with officials from the Forestry Department and Kalulushi Municipal Council. The identified impacts were classified according to the nature of impact, that is positive or negative and significance of impact. Impact significance was determined through consideration of such issues as the likelihood of occurrence, the anticipated magnitude of impact, and duration of the impact. The following possible impacts were identified:-

Positive impacts

- ✓ Employment opportunities for the local population
- ✓ Acquisition of new skills by the local people
- ✓ Improvement of social infrastructure close to the prospect

Negative impacts

- ✓ Dust generation along access roads and during Reverse Circulation (RC) Drilling and sample handling and transport
- ✓ Increase in ambient noise and vibration levels
- ✓ Occupational and inadvertent exposure to dust hazards
- ✓ Loss of vegetation during access roads and drill pads preparation
- ✓ Accidental spillage and leakage of oil at storage areas and drill sites
- ✓ Potential increase in the spread of communicable disease such as HIV and AIDS

These impacts could in turn affect the quality of receptor environmental components such as air quality, noise and vibration, water quality, soil and land use, and the socio-economic environment. The possible impacts on respective environmental components are summarized below together with the suggested mitigation measures.

Since inception of operations, NFC –Africa Mining has been trying to expand its operation to meet increased demand of Copper and Cobalt on the international market. The first expansion was the west orebody, which was achieved in 2008. The current exploration work is aimed at expanding the underground mining operation from current Chambishi mine to Sabina area near the turnoff to Mufulira along the Chingola – Kitwe road.

2.0 THE EXPLORATION PROGRAM

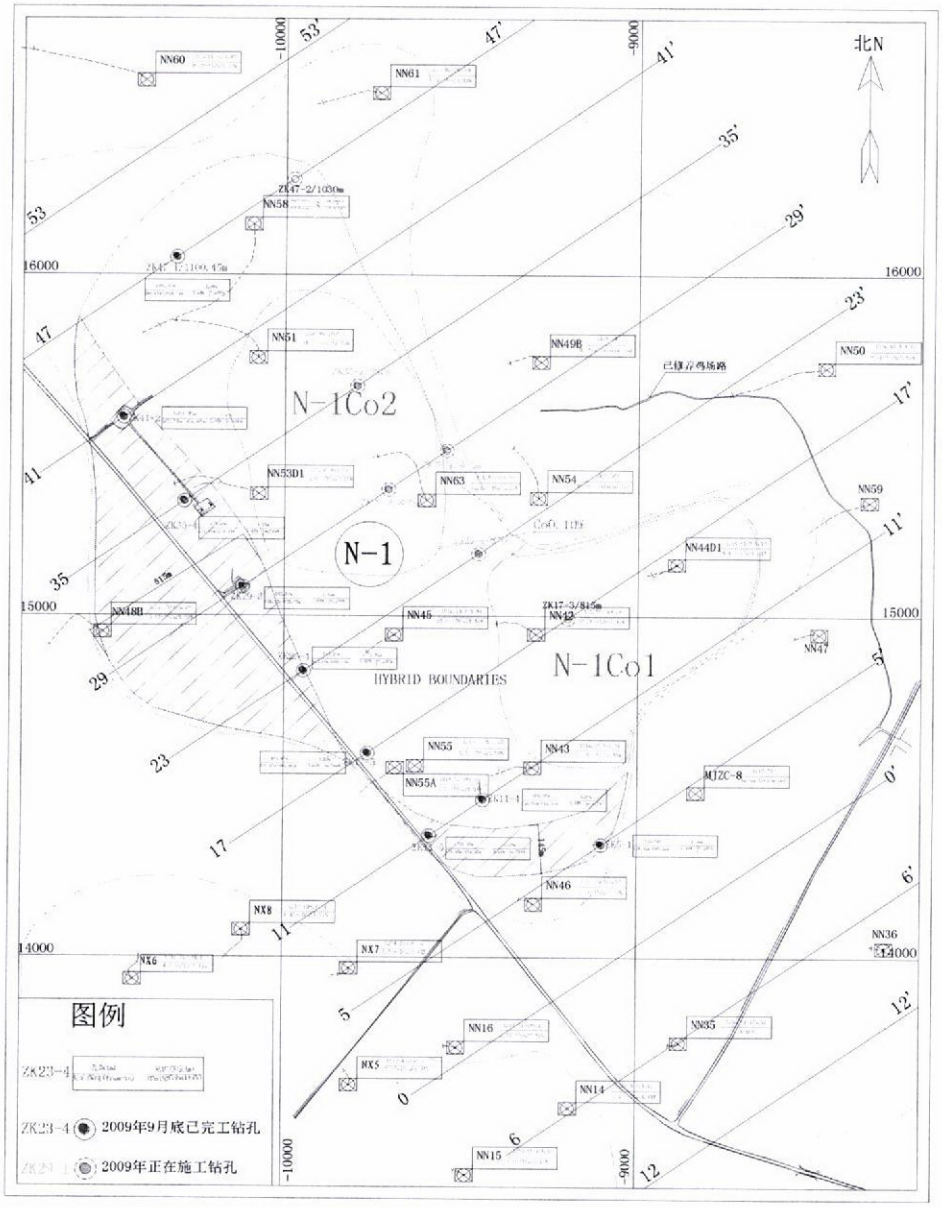
NFC-Africa Mining Plc has identified a potential for eastward expansion of the underground mining activities to exploit both Copper and cobalt. The potential area runs from the current Chambishi mine to the Sabina – Mufulira road almost parallel to the Chingola - Kitwe road. The identified resources lie on both the southern side of the road (near Chambishi current mining operations) and on the northern from Lusala stream to Hybrid poultry farm on the western side of Mufulira road - N2 and N1 orebody respectively (see figure1 above).

Historical information indicates existence of an orebody, southern off shoot of the Chambishi basin where the current mining operations are taking place. The orebody hosts both copper and cobalt in varying ranges both in grade and tonnage. The depth location ranges from 500m in the east to about 2060m on the western end near the Chambishi mine.

The exploration program is phased into three stages;

- Stage one was to do confirmatory drilling for the existence of economically viable orebody in N1 and N2 orebodies or rich zones previously delineated from historical drilling
- Stage two was to conduct the geotechnical exploration drilling of ground condition at depth at locations where service facilities mainly service and ventilation shafts will be.
- Stage three is to proceed with further verification of the quality and quantity of ore in the zones outside zones N1 and N2 – dubbed S1 and S2. This stage is mainly to carter for future expansion and sustainability of operations insurance.

NFC – Africa Mining Plc sought the expert experienced services of Sinomine Resource Exploration Company Limited of China to conduct a detailed exploration to verify the historical data on the existence of the southeast off shoot of the Chambishi basin orebody. This work started with re-examination of the available data and delineated its boundaries. The work started in earnest in December 2008 and by September 2009, the zones had been identified and verification drilling commenced thereafter. The studies identified two main resources; N1 and N2 orebodies separated by a barren zone. The quantities identified are tabulated below in tables 1 & 2:



The expenditure on exploration of the Northern Area of the Southeast orebody project was as follows:
US$ 2544000 was spent on exploration borehole drilling.

3.1.4.3 Minerals distribution characteristics of the Area

From regional correlation, copper ore deposit spreads out in parallel beds along two flanks of Kafue anticline. There are Konkola Copper Mines, Nchanga Copper Mines, Chambishi Copper Mines, Baluba and Luanshya etc. from northwest to southeast in turn on the west of Kafue anticline and many large and ultra large copper ore deposits such as Mufulira Copper Mine while Bwana Mkubwa Copper Mines are on the east of it, thus becoming NW-SE metallogenic belt.

Chambishi Copper Mines is located in northern margin of Chambishi Basin within central SW ore belt while southeast ore field is located in north-eastern flank of Chambishi Basin whose whole altitude is controlled by structure of the basin.

Stratum exposed in the field is mainly a series of metamorphic rocks of low-medium metamorphic grade, forming basement and cover of ore deposit. Basement is composed of Lufubu series and Muva series and its lithology is schist, quartzite, gneissic granite and quartz-mica schist. Overlying sedimentary cover Katanga super-group overlaps unconformably on the basement and it is sedimentary-metamorphic formation transformed from a serious of non-marine clastic rocks by metamorphism. Each stratum in the formation has conformable contact relationship and can be divided into lower Roan, upper Roan, Mwashia and Kundelungu from bottom to top. There are weathering residual and slope washes of quaternary system on Katanga super-group.

Lower Roan: it overlaps unconformably on the basement and we can know that its average thickness is 104.55 m by boreholes. This group stratum can be divided into nine lithologic sections from bottom to top according to lithology

lithologic sections of lower Roan are respectively:

1. Transitional Conglomerate,
2. Feldspathic Quartz Sandstone,
3. Footwall Conglomerate
4. Footwall Quartzite,
5. Dolomite,
6. Mineralized Slate,
7. Upper Quartzite,
8. Interbedded Argillaceous rock and Quartzite,
9. Top Quartzite.

The Mineralized Slate section is a lamellar and banded structure. This is the main ore-bearing horizon of the ore field and its lithology is black, grey black and light grey argillaceous slate and sandy slate. It is a low metamorphic argillaceous and dolomitic sandstone and sandy mudstone. It is located at a depth of 555.20-1014.55 m and the thickness is between 1.25-31.25 m with an average thickness is 17.91 m. This section is divided into footwall argillaceous slate ore body and

east of secondary risings in the central ore field. Thickness of argillaceous rock zone is great in ore-bearing shale of the secondary basin and falling.

3.1.4.5 Ore Deposit Geology

Genesis of southeast ore deposit of Chambishi Copper Mine complies with rift metallogenetic mode of ore deposit. Industrial type of ore deposit is metal polysulphide ore deposit.

Southeast mining area of Chambishi Copper Mines is located in 7 km southeast of main mining area. Mining area is 6 km long from east to west and 5 km wide from north to south, having an area of 30 km^2. Ore body occurs in a series low metamorphic argillaceous and sandy slate and yielded in laminated form. They are folded with surrounding rock. They extend from north to west overall, complying with axial trend of fold structure in the main and plunges towards northeast with inclination of about 5~15°. Altitude in part of section (low-lying section) of ore body is different and ore body extends along its trend and tendency steadily.

Ore body characteristics of north mineralized belt

The rich ore body on which the current project planning is based on is divided into two sections. These lie on the northern side (N1) and southern side (N2) of the Chingola – Kitwe road.

N1 ore body: occurs in a series of low metamorphic argillaceous and sandy slate and yielded in laminated form. They are folded with surrounding rock and located in the north-western flank of syncline. Ore body resembles a "boot" as a whole and extends from north to west. It complies with axial trend of fold structure in the main, declining towards northeast with inclination of 5 -15° and being in line with south-western flank of syncline substantially. Altitude in part of section (low-lying section) of ore body is different. It is 2589 m long along the trend and 569 - 1237m wide along the tendency and extends along its trend and tendency steadily.

In the horizontal direction, plane projection pattern of ore body is irregular banded. In the vertical direction, ore body's buried depth is 550 -1000m and extends from north to west declining towards northeast with inclination of 5-15° and rises from SE to NW. True thickness is 2.32-21.68 m and average thickness is 9.41 m. TCu grade is between 1.59%~5.95% and TCu average grade is 2.30% and Co average grade is 0.116%.

N2 ore body: it is located on the southern side of Chingola road. Along the axis of the ore body it stretches around 900m. In the horizontal direction, plane projection pattern of ore body resembles an oval. In the vertical direction, ore body pattern is in layers with buried depth of 960 -1079m. Inclination of ore body is 0-15° and average inclination is 10°. Thickness is 2.58 -10.72m and average thickness is 8.25m. TCu grade is between 1.92 - 2.29% and TCu average grade is 2.46%.

4.0 Project Description

4.1 Introduction

NFCA Mining Plc intends to mine the Southeast Orefield (ore bodies N-2, N-1, S-1 and S-2) which is located 7km away from the current Chambishi Copper Mine on the southeast. The total copper ore reserves are estimated at 76,345,500 tonnes at an average grade of 2.18%. Production per annum is planned at 3,300,000 tonnes and this gives a total of 25 years of production.

The construction phase will start this year and it's estimated that it will take 5 – 5.5 years. This implies that production shall be scheduled for the second half of 2016.

The life of this mine can be estimated at 25 years of production plus five and half years of construction. Roughly the project will take 30 years excluding years of decommissioning and environmental rehabilitation.

The mine will be scheduled to produce 10,000 tonnes of ore per day and there shall be 330 working days per annum. Work will be done in three eight hour shifts.

The proposed project will gobble a total of US$832 million as total capital investment. This cost includes include capital investment, total working capital and interest on capital.

The project is expected to employ 500 to 1000 Zambians during construction and 5000 Zambians during the operational stage.

4.2 Historical Background

Chambishi Copper Mine was one of the mines under the Zambia Consolidated Copper Mines Limited. It is located in Kalulushi District of the Copperbelt Province of Zambia. Ore resources at Chambishi Copper Mine include the main, footwall and southeast ore bodies

Mining of the main ore body started in 1963, initially using open cast and later using underground mining. By 1978 it reached a production capacity of 6500 tonnes per day and in August 1987 production was suspended because of several reasons, among them improper mining methods, lack of equipment, low funding and low copper prices.

In 1991, the Zambian government began to implement privatisation of state-owned companies and in 1996 China Nonferrous Metal Mining (Group) Company bought the Chambishi Copper Mine through a competitive binding process and on June 29, 1998 China Nonferrous Mining Company Limited signed a development agreement with the Zambian Government in Beijing. This brought about the establishment of NFC Africa Mining Plc, with equity 85% going to China nonferrous Metal Mining Company Limited and 15% to the ZCCM – IH for the Zambian Government.

Figure 4.1; Location of Chambishi Town

4.4 Ore Reserves

Southeast Orefield covers an area of 30 km^2 with length of 6 km from east to west and width of 5 km from south to north.

Southeast ore field is divided into south and north mineralisation zones or belts. Cut off grades of between 1.5 – 1.75% and ore thickness of equal or greater than 2.5m have been used to define the boundaries of the four ore bodies in the Orefield.

In the northern side mineralisation belt N-1 & N-2 have been defined and S-1 & S-2 in the southern belt.

N-1 ore body has 46,473,400 tonnes of copper ore at an average grade of 2.30% TCu and 55,030 tonnes of cobalt ore at an average grade of 0.118%.

Table 4.1: N-1 Ore Reserves

Ore body	Resource Code	Mineral quantity (ten thousand ton)	Weight (t/m^3)	Average grade (%)		Metal Cu (t)	Metal Co (t)
				TCu	Co		
N-1	333	4647.34	2.6	2.30	0.118	1067070	55030

583mL(650~700 m)	22.03	2.13	0.076	188.33	1.74	0.110	321.77	.43	0.110
633m(600~650m)	207.41	2.13	0.076	43.46	1.74	0.110	404.75	2.26	0.110
683mL(550~600 m)	184.34	2.75	0.112				270.20	2.26	0.110
733mL(500~550 m)	303.69	2.75	0.112				198.33	1.67	0.110
783mL(450~500 m)	321.65	2.31	0.119				131.54	1.67	0.110
833mL(400~450 m)	732.48	2.31	0.119				36.43	2.17	0.110
883mL(350~400 m)	521.45	2.25	0.125						
933mL(300~350 m)	230.18	2.25	0.125						
983mL(250~300 m)	1188.58	2.18	0.117						
1033mL(200~250 m)	935.53	2.18	0.117						
Total	4647.34	2.30	0.116	362.17	1.89	0.110	2023.73	1.86	0.110

4.5 Shafts - Preparation/ Planning and Construction Phase

This phase shall include preparation of shaft sinking sites; clearing of site, surveying, marking, and preparation of designs/ drawings and drilling of pilot holes. The pilot holes are necessary as they shall provide data required before the shaft is sank. Activities during preparation/planning and construction phase will also include hoisting river and building sand for concrete and building mortar, laterite for foundations and roads construction, aggregates for concrete and construction of sub base and pavement, waste rock, cement, concrete blocks, and other general building materials (e.g. timber, steel etc) to the project site

4.5.1 Main Shaft

The Main Shaft shall be located 355 metres away from the Kitwe – Chingola Road (western side of the road) between exploration line No. 35 and 41, with x, y

Figure4.2: Main Shaft Hoisting System

4.5.2 Service Shaft

The Auxiliary/ service Shaft shall be located 290 metres away from the Kitwe – Chingola Road (also on the western side of the road) between exploration line No. 35 and 41, with x, y and z coordinates as 15288.000, 10750.000 and 1233.000 respectively. The shaft shall be round with a diameter of 7.2 metres and depth of 1133 metres.

4.5.3 South Ventilation Shaft

The South ventilation shaft will be located on the western side of the Kitwe – Chingola Road 301metres. This position is southeast of N-1 Ore body and near No.11 prospecting line with x, y and z coordinates as 14125.000, 9840.00 and 1218.000 respectively. The shaft shall be round with diameter of 6.5 metres and depth of 668 metres. A pilot hole of 650 metres has already been drilled to expedite the sinking of South Ventilation Shaft.

4.5.4 North Ventilation Shaft

The Ventilation Shaft shall be located on the western side of the Kitwe – Chingola Road approximately 300 metres away. This position is between Ore bodies N-1 and N-2 near prospecting line No.65 and closer to N-2 Ore body. The shaft will be round with diameter 6.5 metres and depth of 936 metres. A pilot hole will be drilled before the sinking of the north Ventilation Shaft.

4.5.5 Alternative 2: Shaft Locations and Design

Alternatively the main and service shafts shall be located between No. 23 and 29 prospecting lines with a special fresh air intake shaft, which shall be located at west side of N-1 Ore body near No. 41 prospecting line. In this alternative the special intake shaft shall be more than 500 m away from the Chingola – Kitwe on the same side where all the shafts will be located. Road The north ventilation shaft in this alternative will be located at west side of N-1 Ore body on No.47 prospecting line and the south ventilation shaft will be located at south side of the N-1 Ore body near No. 11 prospecting line. All ventilation shafts shall be round with diameter of 6.5 m. below are the positional coordinates and depth of the shafts:

The head frame for the main shaft and the service shaft shall be 1222m and 1220m respectively. In this alternative the winding/ hoisting house installations will be the same as in the preferred proposed design.

In addition alternative 2 will have a Special fresh air intake shaft which shall be used as an air inlet for north mining area.

This alternative is not economical and has not been adopted.

Table4. 4: Alternative 2 for Shaft Location and Design

Shaft Name	X - Coordinate	Y-Coordinate	Z-Coordinate	Depth (m)	Diameter (m)
Main Shaft	14813.700	10416.200	1222.000	1167	6.5
Service Shaft	14739.000	10366.000	1220.000	1120	7.2
Special Intake shaft	15280.000	10805.000	1235.000	935	6.5

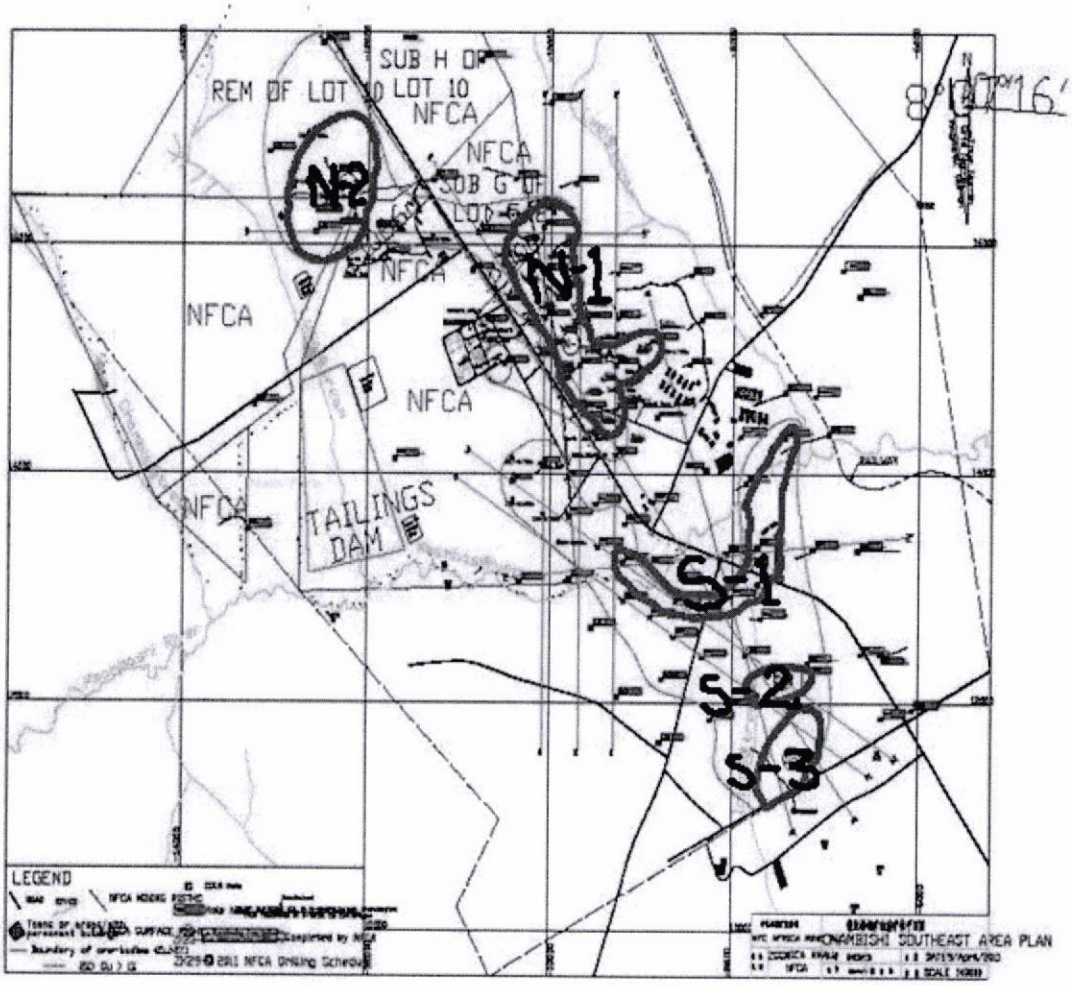


Figure4.4: Location of the Ore bodies

4.6 Shafts – Operational Phase

4.6.1 Main Shaft

The main shaft will serve as a down cast air intake and a double decked 23 m^3 bottom-emptying skip with steel guides shall hoist ore and or waste and a 5600kW rating, JKMD5×4 (Ⅲ) E ground-mounted multi-rope hoists in the winding/hoist house shall run the skip up and down the main shaft.

4.6.2 Service Shaft

The auxiliary shaft shall serve as a down cast for fresh air intake into the mine and shall also be used to take equipment in and out of the mine. It shall also be used for man riding. It shall also be used to hoist materials in and out of the mine.

4.7.4 North Ventilation Shaft

The main fans shall be uninstalled taken out of the plant and there shall be no more air being up casted from underground. The shaft collar shall be blasted and barricaded. The shaft collar shall be plugged, re-profiled and re-vegetated. Warning signs shall be placed around the barricade.

4.7.5 Special Intake Shaft

The shaft collar shall be blasted. The shaft collar shall be plugged, re-profiled and re-vegetated. Barricades and warning signs placed around.

4.8 Underground Infrastructure – Preparation/planning and Construction Phase

4.8.1 Pump Chamber

The pump station shall be located at 1035mL.

4.8.2 Crushing Chamber

The main tips shall lead to the crusher chamber which shall be installed with two sets of crushers at about 55m below Level 1033m.

Crushing chamber will be located at 1088mL between the main shaft and service shaft.

4.8.3 Production and Tramming Levels

Levels at 753m, 903m and 1033m will be tramming levels / main haulages. The service shaft will connect with various production levels through horse head doors at 753mL, 833mL, 903mL, 933mL, and 1033mL and connect with the crusher chambers at 1088 mL.

4.8.4 Mine Dewatering

It has been estimated that southeast ore body has the potential to discharge between 42000 – 90000 m^3/ d into the mine drainage.

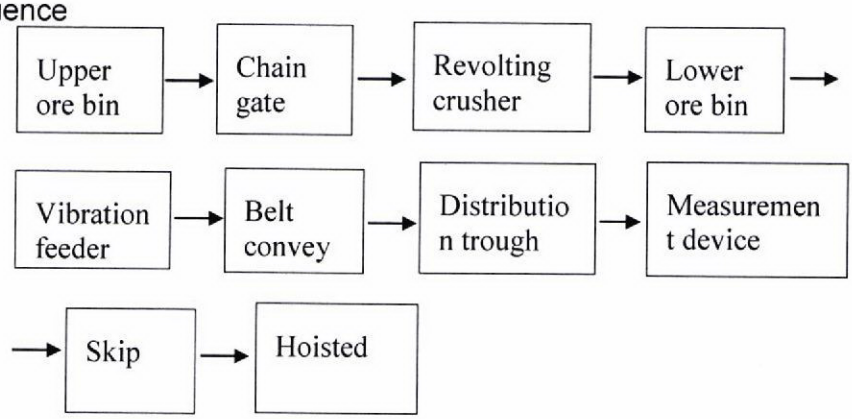
4.8.4.1 Drainage system

The underground pump station, transformer substation and water sump will be located around 1033mL.

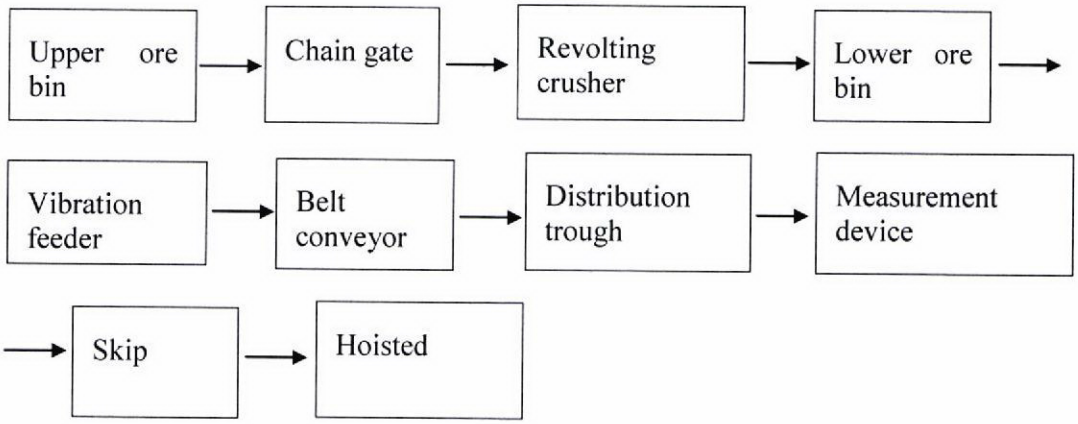
4.8.4.2 Sludge Discharge system from the water sump

After the mud has settled to the bottom of the water sump, the clear water will be pumped to water storage dam ready to be pumped to the surface and from the bottom of the water sump all the sludge will be drained and or pumped out and disposed of on top of the waste rock dump. This will enhance soil fertility for re-vegetation. Alternatively the sludge will be disposed to the tailings dump.

Ore Crushing Sequence



Waste Rock Crushing Sequence



4.9.8 Diesel Depot

Two 23,000 litres capacity diesel tanks shall be installed in the diesel deport and all loaders, vehicles and any other machinery that use diesel shall refuel in the diesel deport.

4.9.9 Waiting Room, Material Warehouse and Rock Drills Shop

Locomotives and Granby cars shall be repaired and maintained in the loco shop. There shall be a waiting room for the workers to assemble in to receive their daily safety act and work for each particular day. Accessories that are required by all mining activities underground shall be stored in a materials warehouse. All rock drills accessories like drill steels, shanks, bits etc shall be stored in the rock drills shop.

4.10 Underground Infrastructure – Closure/ Decommissioning Phase

4.10.1 Crushing Chamber

At closure the crushers will be uninstalled and taken out of the mine with any accessories that could be reclaimed. The crushing chamber will then be barricaded and decommissioned.

4.10.2 Pump Chamber

The pumps and any other accessories that can be reclaimed will be uninstalled and hoisted to the surface of the mine and the chamber decommissioned. Entrances to the chamber will be barricaded.

4.10.3 Production and Tramming Levels

At close power, compressed air and water supply will be disconnected. Compressed air pipes and power supply cables and water pipes reclaimed and brought to the surface of the mine. Entrances to production levels, draw cross cuts, scrapper drifts, drives and tips barricaded and decommissioned.

On tramming levels water, electricity and compressed air shall be disconnected. All pipe networks reclaimed and taken to the surface.

The trolley line, rails, locomotives and Granby cars taken to the surface and all loops and haulages barricaded and decommissioned.

4.10.4 Mine Dewatering

4.10.4.1 Drainage system

The drainage network will continue to collect water from all working levels to the pump chamber in the sumps.

Table4.6: Total Area to be covered by infrastructure

	Building Type	Area (m^2)
1	Industrial buildings	22573
2	Office Block	585
3	Total	23158

Table4.7: Materials and Quantities of Materials

	Material	Quantity (t)
1	Steel	2939
2	Reinforcement	603
3	Cement	5539

4.11.2 Surface Ore Bin

The surface ore bins shall cover an area of 820 square metres and have dimensions 2φ15m X28.8 m. It shall have reinforced raft concrete foundation, reinforced wall. It shall consume 89 tonnes of steel and 442 tonnes of cement at construction phase.

4.11.3 Flotation building

The flotation plant will be 90m X24m X15.5m in length, width and height respectively. It shall be constructed of reinforced beam foundation, sandwich steel slab and plasterboard wall. It shall consume a total of 184 tonnes of steel and 450 tonnes of cement.

4.11.4 Main Building

The main building shall have axial dimensions of 90×72.87×18 metres in length, width and height respectively. It shall be constructed of reinforced beam foundation, sandwich steel slab and plasterboard wall. It shall consume a total of 990 tonnes of steel and 1450 tonnes of cement.

4.11.13 Main Shaft Head Frame

Head frame for the main shaft shall be 32 metres tall, made of steel frames and shall have a reinforced concrete foundation. It shall consume a total of 480 tonnes of steel and 150 tonnes of cement.

4.11.14 Service Shaft Head Frame

Head frame for the service shaft shall be 50 metres tall, made of steel frames and shall have a reinforced concrete foundation. It shall consume a total of 690 tonnes of steel and 220 tonnes of cement.

4.11.15 Main Fan Electronic Control Room

The main fan electronic room will have axial dimensions of 6×6×6 metres in length, width and height respectively. It shall have a reinforced concrete foundation and sandwich steel slab wall. It shall consume a total of 2 tonnes of steel and 1 tonnes of cement.

4.11.16 Maintenance building

The maintenance building shall have axial dimensions of 30×12×6 metres in length, width and height respectively. It shall have a reinforced concrete foundation, sandwich steel slab and a plasterboard wall. It shall consume a total of 25 tonnes of steel and 20 tonnes of cement.

4.11.17 Hoist room of service shaft

The service shaft hoist room shall have axial dimensions of 21×18×15 metres in length, width and height respectively. It shall have a reinforced concrete foundation, sandwich steel slab and a plasterboard wall. It shall consume a total of 25 tonnes of steel and 22 tonnes of cement.

4.11.18 Hoist room of main shaft

The main shaft hoist room shall have axial dimensions of 18×18×15 metres in length, width and height respectively. It shall have a reinforced concrete foundation, sandwich steel slab and a plasterboard wall. It shall consume a total of 24 tonnes of steel and 20 tonnes of cement.

4.11.19 Main step-down substation

The main step down substation shall have axial dimensions of 27.5×10×12 metres in length, width and height respectively. It shall have a reinforced concrete foundation, cast in place reinforced column and a masonry wall. It shall consume a total of 52 tonnes of steel and 153 tonnes of cement.

4.11.20 Tailings conveying building

The tailings conveying building shall have axial dimensions of 48×21×5 metres in length, width and height respectively. It shall have a reinforced concrete foundation, sandwich steel slab and a plasterboard wall. It shall consume a total of 70 tonnes of steel and 32 tonnes of cement.

concrete foundation, steel plate wall and a steel column. It shall consume a total of 60 tonnes of steel and 20 tonnes of cement.

4.11.30 Service Roads

The total road network in the southeast Orefield is estimated to be 2.95 kilometres long. There will be three kinds of roads at the proposed southeast Orefield depending on its functions and properties.

There shall be roads for ferrying of mine personnel from the township to the mine site, roads that will be used for the transportation of waste rock to the waste rock dump and the road for maintaining the tailings pipeline and dam.

No.	Name of building	Axial dimensions (L x W x H m)	Building indexes		Characteristics of building structure										
			Building area (㎡)	Structure volume (m^3)	Wall			Column foundation	Column	Slab (platform)	Roof		Doors and windows	Steel (t)	Cement (t)
					Foundation	External wall	Internal wall				Bearing structure	Insulation and water proofing			
7	φ30 thickening basin	φ30X3.5	707	2473	Reinforced concrete raft foundation									45	220
8	Canteen	30X12X3	360	1080	Foundation beam	Sandwich steel slab	Plasterboard wall	Reinforced concrete foundation	Steel column		Steel beam	Sandwich steel slab	Plastic steel doors and windows	35	60
9	Return pump station	21X9X6	189	1134	Foundation beam	Masonry wall	Masonry wall	Reinforced concrete foundation	Cast-in-place reinforced concrete column	Steel platform	Steel beam	Sandwich steel slab	Plastic steel doors and windows	18	54
10	Circulating water pump station 5,000m^3-water tank	Pump 36X9X6	324	1944	Foundation beam	Masonry wall	Masonry wall	Reinforced concrete foundation	Cast-in-place reinforced concrete column	Steel platform	Steel beam	Sandwich steel slab	Plastic steel doors and windows	155	710
11	Water pump station for production and fire protection 5,000m^3-water tank	Pump 30X9X6	270	1620	Foundation beam	Masonry wall	Masonry wall	Reinforced concrete foundation	Cast-in-place reinforced concrete column	Steel platform	Steel beam	Sandwich steel slab	Plastic steel doors and windows	150	700
12	32m-high steel head frame							Reinforced concrete foundation	Steel frame					480	150

No.	Name of building	Axial dimensions (L x W x H m)	Building indexes		Characteristics of building structure										
			Building area (㎡)	Structure volume (m^3)	Wall			Column foundation	Column	Slab (platform)	Roof		Doors and windows	Steel (t)	Cement (t)
					Foundation	External wall	Internal wall				Bearing structure	Insulation and water proofing			
													windows		
20	Stowing system building (4 buildings)	18X18X15	1296	19440	Foundation beam	Sandwich steel slab	Plasterboard wall	Reinforced concrete foundation	Steel column		Steel beam	Sandwich steel slab	Plastic steel doors and windows	180	110
21	Material warehouse	45X12X4	540	2160	Foundation beam	Sandwich steel slab	Plasterboard wall	Reinforced concrete foundation	Steel column		Steel beam	Sandwich steel slab	Plastic steel doors and windows	16	14
22	Fire house	40X9X4	360	1440	Foundation beam	Sandwich steel slab	Plasterboard wall	Reinforced concrete foundation	Steel column		Steel beam	Sandwich steel slab	Plastic steel doors and windows	11	10
23	Guards' room	12X6X2.8	72	202	Foundation beam	Sandwich steel slab	Plasterboard wall	Reinforced concrete foundation	Steel column		Steel beam	Sandwich steel slab	Plastic steel doors and windows	2	2
24	Initiating materials warehouse	18X6X3	108	324	Foundation beam	Large prefabricated wall board	Large prefabricated wall board	Reinforced concrete single foundation under column	Cast-in-place reinforced concrete column		Cast-in-place reinforced concrete	EPS board for insulation and APP for water proofing	Wood doors and plastic steel windows	7	20
25	Detonator warehouse	18X6X3	108	324	Foundation beam	Large prefabricated wall board	Large prefabricated wall board	Reinforced concrete single foundation	Cast-in-place reinforced concrete		Cast-in-place reinforced	EPS board for insulation and APP	Wood doors and plastic steel	7	20

4.11.31 Volume of Material to be transported

The total volume of material to be transported outside and inside the proposed project site has been estimated at 4,261,680 tonnes per annum.

Table 4.9: Volume of Transport per annum

No.	Cargo Name	Unit	Quantity	Source	Destination	Method
1	Dynamite	t/a	1926	Outside Factory	In-factory	Automobile
2	Non-electrical detonator	Ten thousands/a	47.66	Outside Factory	In-factory	Automobile
3	Nonel	Ten thousands/a	296.27	Outside Factory	In-factory	Automobile
4	Drill	Piece/a	4829	Outside Factory	In-factory	Automobile
5	Drill stem	Piece/a	475	Outside Factory	In-factory	Automobile
6	Drill shank	Piece/a	271	Outside Factory	In-factory	Automobile
7	Tyre	Piece/a	476	Outside Factory	In-factory	Automobile
8	Oils	Million litre/a	128.4	Outside Factory	In-factory	Automobile
9	Cement	t/a	72703	Outside Factory	Backfill station	Automobile
10	Steel ball	t/a	1980	Outside Factory	Ore dressing plant	Automobile
11	Liner	t/a	660	Outside Factory	Ore dressing plant	Automobile
12	Adhesive	m^2	1650	Outside	Ore dressing	Automobile

Within the mining area there shall be 4 x 32 tonnes dump trucks (one on standby), 3 scrappers (one on standby) having a loading capacity of 5 cubic metres.

Automobiles for the living quarters: equipping commuters to carrying the workers go to and from the compound, as well as the necessary liaison cars for business. It is initially determined as following:

Table 4.10: Transporting Equipment

	Equipment Name	Units	Capacity
1	Dump Truck	4	32 ton
2	Front End loader	3	$5m^3$
3	Coaches	5	65 passengers
4	Fire Engine	2	-
5	Ambulance	2	-
6	Sprinkler	2	-
7	Sedan	2	-
8	Off road vehicle	2	-

4.11.33 Waste Disposal Site

The site will be serviced by oxidation ponds type of arrangement for the biological treatment of sewer waste. All places that will have offices and shower rooms shall channel its sewer to this treatment system. The effluent from the ponds will be recycled for flushing toilets and greening the site any excess will be discharged to the environment after disinfection through an approved and licensed site by ZEMA. The company will acquire a license for the facility from ZEMA

An area of size 300 X 300 metres shall be designated as a non hazardous solid waste disposal site. The company will acquire a license from ZEMA to operate this disposal site. This site shall carter for all waste except hazardous waste and domestic waste.

4.12.6 Tailings Thickener

The thickener shall separate the tails and water. The under flow shall collect as tailings and the overflow shall be water without solids. This water will be re-circulated back into the plant and used as process water. The tails will report to the backfill plant where some will be used as fill material for the stopes underground and some will be taken through a pipeline to the tailings dam for final disposal.

The thickener basin shall store the under flow material from the thickener before it is transferred to the backfill plant or the tailings dam.

4.12.8 Canteen Building

The canteen building shall be used as a kitchen for cooking meals for the employees at the mine. Employees will be required to buy meals at their own expenses..

4.12.9 Return Water Pump Station

The decanted clean water from the tailings dam will be passed to a re-circulating pump station and conveyed to the re-circulated water sump.

With flow rates of 8500 m^3/day re-circulated water will be used for industrial purposes only. The re-circulation water pump station shall be equipped with two 250SS90O type water pumps each having a power rating of 220KW. Only one shall be in use at any time, the other one shall be on stand by. The PVC pipe type shall be used in the re-circulation water sump station.

4.12.10 Circulating Water Pump Station

The circulating water pump station will be equipped with water pumps to keep pumping the water in the water circuit to all the departments and required operations.

4.12.11 Water pump station for production and fire protection

4.12.11.1 Water supply

The source of water for the proposed project will be from underground. This shall constitute both domestic water and industrial water supply. The sections 5.6.1 to 5.6.6 describe activities of water supply during the operational phase. The preparation / planning phase of the water supply system shall involve clearing and levelling the water treatment and septic soak way sites, surveying and marking out the exact dimensions and preparation of drawings for the water treatment plant and the septic tank and soak way system. This phase shall also incorporate siting and doing the drawings of the pump station.

Construction stage shall involve digging, compacting the floor and lining of the reservoir, construction of the pump station and installation of pumps, digging and construction of the septic tank and soak way biological treatment compartments.

4.12.18 Main step-down substation

The main step down substation shall be equipped with a step down transformer and shall reduce the voltage from the 33kV to what is required by different departments and activities.

4.12.19 Tailings conveying building (Backfill Plant)

The tailings conveying building will receive the tailings from concentrating process and transfer the under flow to underground stopes and the overflow to the tailings dam for final disposal. It will save as a backfill plant.

4.12.20 Stowing system building

This is where tailings will be treated. The pH of the tailings will be neutral. The final concentrator tailings leaving scavenger cells will be pumped to a back fill plant for classification. Hydrocyclones will be used to classify the tailings into coarse sand and fines. The coarse fraction will be mixed with some cement and pumped to the worked out stopes underground where it will be used as back fill to fill the holes left after mining out the ore in the stopes. The fines will be pumped to the tailings dam for final disposal.

4.12.21 Warehouse

The warehouse building shall be use to store materials required in different departments when they are brought to the mine site..

4.12.22 Fire Station

In the estimation of water supply for the purpose of fire fighting at the mine it is assumed that the mine catches fire at the same time and it has duration of 2 hours. The fire fighting water supply network shall draw water from the 5000 cubic metres storage reservoir at the mine. This shall be the same reservoir that shall provide domestic and industrial / process water. Two XBD10/30-125G/5 type fire pumps with a power rating of 450kW per unit shall be installed at the pump station for the purpose of drawing water in case of fire at the mine site. Each pump shall be able to pump as much as 40 L/s and only one pump will be used at a time if a fire occurred. The other one shall be on stand by.

A 160 cubic metres water storage tank shall be installed on the rooftop of the tallest building to store water for fire fighting purposes. Fire fighting water supply network pipes shall employ galvanised steel pipes.

Portable dry powder fire extinguishers will be placed at strategic designated places in plant area to be used for fire fighting in case of any fire.

4.12.23 Security Guards' Room

The security guards' room shall be used as a security check point at the entrance of the plant. Employees and contractors entering the plant will have to be checked before entering and leaving the plant. Vehicles and trucks shall also be checked likewise.

suspended in the water to settle at the bottom and there by only clear water will be discharged. In situations when there shall be inadequate process water supply clear water from the sedimentation pond shall be taken back into the plant to be used as process water

4.13 Surface Infrastructure – Closure/ Decommissioning Phase

The surface infrastructure will require disconnection of power supply, reclamation of any materials that can be used elsewhere, demolition of concrete foundations and walls, grading, re-profiling and re-vegetation of the grounds.

The power line and its associated infrastructure (transformers) shall be uninstalled. The Southeast Orefield shall first be isolated from power (Cut from power), power lines uninstalled, poles dug out and removed, the way leave re-vegetated.

4.14 Mining Methods

The preparation/ planning of mining methods involved reviewing of different mining methods in relation to the southeast ore body characteristics, selection and design of the chosen mining method. Post pillar Sublevel Backfill and Room & Pillar Backfill Mining Methods were selected depending on the dip and thickness of the ore body. Figure 4.5 and 4.6 show the detailed designs of the post pillar sublevel and room & pillar backfill mining methods respectively.

Construction phase involves mining of the primary and secondary development. This development constitute mining such infrastructure as the ore pass sublevel drifts (footwall drives), access cross cuts, ventilation raises, drainage drives and raises, mining drives (access to the ore body). The construction stage prepares a stope for long hole drilling and finally blasting.

Closure/ decommissioning of stopes underground will be progressive. This implies that as one stope is fully developed; blasting and the production will follow. Once the stope has produced its expected tonnage (depending on grades), access to the stope will be closed and barricaded and if there is need to seal, that will be done in order to control the air flow.

4.14.1 Ore body Characteristics

The Southeast Ore body is one of deposits in the mineral exploitation license of NFC Africa Mining PLC. The Southeast ore body occurs between foot conglomerate of the basement granite and dolomite argillite. It is a strata bound and shale type copper ore deposit and can be divided into three sections the footwall schist ore, main ore and roof argillaceous ore. There are two mineralized belts in Southeast Ore body, the North belt with N-1, N-2 and the South belt with S-1 and S-2 ore bodies

The southeast ore body lies at a depth of between 550~1000 metres, displaying smoothly waving configuration. The horizontal project area is approximately 2.0km^2. The thickness of ore body ranges from 2.32 to 21.68 metres, with average thickness of 9.41 metres. The dip ranges between 5~15°.

$$S = \frac{R_c}{300} \cdot RQD$$

Where;

S is the Rockmass quality index;

R_c is the UCS of rock;

RQD is the rock quality index and it is equal to ratio between the length of the core which is longer than 10cm and the total length of the drilll core

The hanging wall rocks are mainly Lower Roan sandstone and argillaceous quartzite, with a thickness of 15 to 30 metres and saturated UCS of 56MPa (sandstone) and 132MPa (argillaceous quartzite), with an average of 94MPa, and RQD of 97%. S is equal to 0.30 according to the above formula and the rock mass quality can be assessed as being medium.

The ore body is chalcopyrite and pyrite sandy slate, with an average thickness of 20 metres, saturated UCS of 55MPa and RQD of 98%. S is equal to 0.19 and the rock mass quality can be assessed as medium.

The footwall is quartzite and argillaceous conglomerate, with an average thickness 10 – 50 metres, saturated UCS of 99MPa (quartzite) and 77MPa (argillaceous conglomerate). This gives an average of 87MPa and RQD of 98%. S is 0.28 and the rock mass quality can be classified as medium.

4.14.3 Hydro geological conditions

The main aquifers in the mining area are the weak water-rich Quaternary, weak water-rich weathering zone, the Upper Roan group with structural karst breccia middle water-rich. There is a huge impermeable layer with a thickness of 180 - 530 meter in the roof strata. During exploration, no hydraulic conductive structures were found in the impermeable layer and some straight cleavages with a linear fracture rate of 0.3 per metre was found occasionally. So the groundwater has no direct impact on the ore deposit water content.

Naturally, there are no direct hydraulic connections between the streams/ rivers and the main aquifers. And due to the huge thick impermeable layer in the roof, the surface waters have no direct impact on the ore deposit water content.

4.14.4 Cut and Fill Mining Method – General Principle

Cut and fill stoping, is normally an overhand and replaced mining method in which horizontal slices of ore are excavated in the stope and replaced with waste as fill. The fill can be a combination of waste rock and tailings. The filling is

4.14.6 Post Pillar Stoping

The post-pillar method is used for wide ore bodies with a greater vertical extent than can be mined with the room and pillar method. As each horizontal cut is mined and backfilled, pillars are maintained to support the back. Pillars become tall and slender, but the backfill prevents buckling.

Ore competency should be good to prevent pillar and back failure. Post-pillar can be classified as an overhand stoping method.

4.14.7 Unsupported Backs

In competent ore, the stope back may require little or no support. An occasional rock bolt or stull may be required to support a loosened slab.

4.14.8 Rock-bolted Backs

The most common method of back support in overhand stopes is the installation of rock bolts on a pattern after each blast. This minimizes the extent of unsupported back that men must work near or under. Rock bolts prove to be a nuisance when mining the next cut, however, because blast holes may be drilled into an installed rock bolt, and rock bolts have to be manually removed from the broken ore.

4.14.9 Reasons for Selecting Cut and Fill

4.14.9.1 Ore Body Geometry

The shape of an ore body is important to the selection of a mining method. Cut and fill methods are almost always considered for steeply dipping veins. Most cut and fill stoping and development methods rely to some extent on gravity flow of broken rock, and thus veins with dips less than the angle of repose (< 45°) of broken rock must be mined using footwall or hanging wall development.

Irregular ore bodies, such as replacement ore bodies, are often candidates for cut and fill mining.

Whenever mining requires manned stopes with potentially high backs and walls, cut and fill mining is used to improve safety and wall support by limiting the working height of a stope. Backfill provides a working floor at a convenient elevation for mining activities.

4.14.9.2 Mining Selectivity/Grade Control

Because of the limited open volume of cut and fill stopes and the wall supporting function of backfill, very irregular surfaces can be followed precisely. Greater selectivity results in a higher grade ore product, which is important to the economics of a mining operation.

4.14.9.9 Cost

Cost is a primary consideration in the choice of a mining method (see 19.1.5). Cut and fill mining will generally be more expensive than open stoping. However, the previous criteria may rule out all methods except cut and fill, or the reduction in dilution may be financially attractive and justifiable.

4.14.11 Mining methods to be adopted

The Southeast Ore body is an underlain deposit; at a depth of 550 - 1000 metres with average thickness of 9.35 metres. Open pit is not suitable. The ore body will be exploited using underground mining methods.

It is planned that the ore body will be mined using post pillar mechanized sublevel backfill mining method and room & pillar delayed backfilled mining methods depending on ore thickness and dip.

Where the ore body has thickness greater than 10 metres and dipping between 15 and 20 degrees, post pillar mechanized sublevel backfill mining method will be adopted Where the ore body is less than 6 metres thick and dip less than 10 degrees, room & pillar delayed backfill mining method will be employed.

All these two fall in the category of cut and fill mining method.

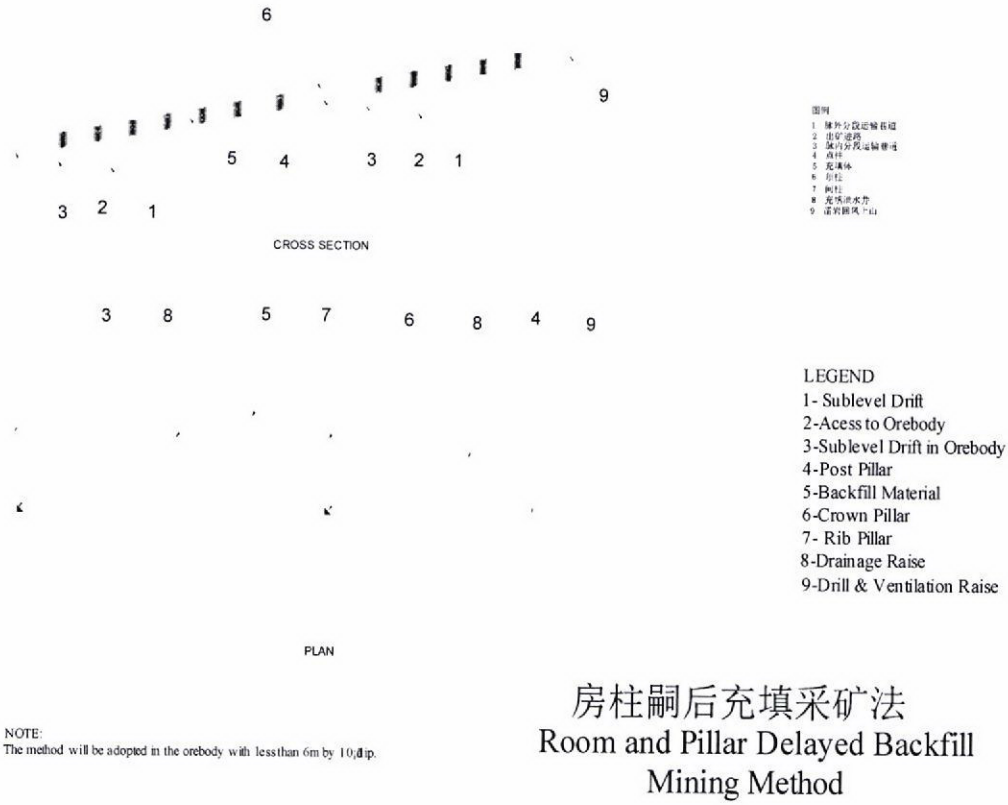


Figure4.6: Room and Pillar Delayed backfill Mining Method

The formula below can be used to calculate the caving height of the caving zone in practice:

$$h = \frac{m}{(k-1)\cos\alpha}$$

Where; h is the height of caving zone;

m is the height of mined out void;

k is the broken swell index;

α is the dip of ore body.

4.14.14 Crack Zone

The overlaying rock, in which the cracks, separations and fractures come into being, but maintaining a layered structure, is called crack zone. It beds between the caving zone and curving zone, and larger cracks, deformations and failures will appear in it. The failure features are not only the cracks and fractures which are vertical to the bedding planes but also the separations are parallel.

When mining under the water, the caving zone and crack zone is called hydraulic conductivity fracture zone. The height of hydraulic conductivity fracture is related to rock characteristics. For the weak rocks, the height is 9 to 12 times of the mined height. For the moderate rocks, the height is 12 to 18 times of the mined height. For hard rocks, the height is 18 to 28 times of the mined height.

4.14.15 Curving zone

The curving zone refers to the whole rocks above the crack zone up to the surface, the strata movement features are as following: there will be continuous and regular movement, but the stratum maintain integrity and layered structure, and some separations will appear in the lower part of the zone. In the vertical sections, the sediment difference among all parts is minimal. The curving zone height is mainly impacted by the mining depth. When the mining depth is small, the curving zone does not exist, and the hydraulic conductivity fracture zone will be up to the surface. When the mining depth is large enough, the height of curving zone can be much higher than the sum of the heights caving zone and crack zone. And the underground mining will not affect little to the surface.

The factors of deformation, Mining depth, the dip of the ore body; the shape of the ore body in plan; the strength of the ore body; the strength of the surrounding country rock; the strength of the overburden or cap rock; the presence of major structural features such as faults and dykes intersecting the ore body and cap rock, the depth of mining as defined by the undercut level and the associated in situ stress field, the slope of the ground surface; any prior surface mining; the placement of fill in a pre-existing or newly produced crater; and nearby underground excavations.

The Southeast ore body bedded gently dipping at 10 degrees on average, moderate thickness of 10 metres and located between 550 – 1000 metres below the surface. The post pillar backfilled mining method and room & pillar delayed backfill method will be used, so many substantial rib pillars will be planned to be left to support the roof, the ratio of pillar to stope is about 20~30%.

Void treatment by strip packing or hydraulic or pneumatic solid stowing can reduce the subsidence in a single panel by more than 50% depending on the nature and timing of the treatment. The largest reductions are obtained for solid stowing carried out immediately after mining. Stowing has been used successfully in Europe, India, the UK and the USA, for example, to control subsidence, particularly for thick seam and multi-seam extraction. However, it adds to mining costs and has an impact on rates of production in highly mechanized operations.

In the Southeast Orefield, the backfill mining methods will be used, so the voids will be filled with waste or classified tailings or paste backfill material in time, the roof rock of the void will be supported and then the subsidence or failure can be controlled effectively and reduce the extent or height of the caving and crack zone.

Harmonic extraction involves the phased removal of the mineral from a critical area such that the ground surface is lowered smoothly and horizontal strains are minimized. The technique may be used to protect structures that are especially important or susceptible to subsidence -induced damage. Harmonic extraction requires that the panel be advanced in at least two faces maintained at a carefully calculated distance apart. The orientation of the structure with respect to the direction of face advance determines whether protection against the transverse or the longitudinal surface wave is the more important. Peng (1992) provides illustrations of harmonic extraction in single and multi-seam mining, but indicates that the method is only applicable when a single entry system between panels is used.

In Southeast Ore body mining plan, the excavation schedule should be carefully calculated and arranged in order to realize the harmonic excavation to protect the ground surface such as the main roads, rivers & streams and farms etc.

4.14.17 Possible impact of Underground Mining

Given that the swell index is 1.5, average ore thickness being 10 metres and the dip of 10 degrees and assuming no rib pillar left and no backfilling done, the height of caving can be estimated as;

stope shall be filled with solids and there shall be no subsidence or caving of ground.

The process of Backfill plant will be fully automated and computerised. The use of cement in the mixing process in the agitator will ensure that the backfill material will give high strength of fill, relative good stability and no weathering of filled in material once deposited in the stope.

4.15 Ore Processing Methods

4.15.1 Process Flowsheet

The process flow sheet for the proposed concentrator for the Chambishi Southeast ore is summarized in figure 4.10. Run-of-mine ore will be crushed to – 225mm at an underground crushing plant and hoisted by skip to the surface where a conveyor belt will transport it to a coarse ore bin (effective storage capacity of bin will be 10000 tonnes). Crushed ore from the bin will be fed onto a conveyor belt by a vibratory feeder and transported to a semi autogenous (SAG) mill for coarse grinding to 20% - 75 microns (i.e. 20% -200 mesh). Ore slurry from the SAG mill will flow to a sump by gravity. Ore slurry from the sump will be pumped to hydrocyclones for classification. Overflow from hydrocyclones will flow to the flotation plant whilst underflow sands will flow to a ball mill for further grinding. Ore slurry from the ball mill will flow into a sump from where it will be pumped back to the hydrocyclones. The fineness of grind for the ore will be 65% - 75 microns.

Cyclone overflow from the grinding circuit will flow into an agitation tank for mixing with flotation reagents. Ore slurry from the agitation tank will be pumped to the roughing flotation machines. Concentrate from roughing will be pumped to three cleaning stages whilst rougher tailings will be pumped to two scavenging stages. Cleaned concentrate from stage 1 will be re-cleaned in stages 2 and 3 to make a final concentrate assaying 24% copper and 0.6% cobalt.

The copper concentrate will flow to a thickener whilst thickener underflow (60% solids w/w) will be pumped to ceramic filters for filtration to attain a final moisture content of 8 – 10%. The filtered concentrate will be transported to Chambishi Smelter by road trucks.

Final tailings from scavenging stage 2 assaying 0.26% copper and 0.06% cobalt will be pumped to a grading plant where sands will be separated out for use as backfill in mining operations while fines will be pumped to a tailings dam for disposal.

4.15.2 Ore Transportation

The run-of-mine ore will be transported by conveyor belt to the underground crushing plant. Ore from the crushing plant to the coarse ore bin will be transported by skip and from ore bin to SAG mill transportation will be by conveyor belt. From the SAG mill to the rest of the concentrator ore will be in slurry form and transportation between the various stages will be by pipes and pumps. Filtered copper concentrate will be transported by conveyor belt to the loading bay and then by road trucks to the smelter.

4.15.3 Process Buildings

Process sheds to be constructed at the site will include:

- Conveyor belt corridor
- Coarse ore bin
- Grinding and flotation building
- Copper concentrate thickening and pumping station
- Filtration plant building
- Tailings thickener
- Tailings Pump House

4.15.4 Non-Process Buildings

Non-process buildings to be constructed at the site include:

- Administration offices
- Ablution facilities and change room
- Gate house, security and access control area
- Laboratory
- Engineering workshops

4.15.5.Tailings Disposal

Tailings from the concentrator will be produced at the rate of 9209 tonnes per day (or 3,038,970 tonnes per annum) assaying 0.26% copper and 0.06% cobalt. A tailings dam will be constructed on the Lusala stream and tailings from concentrator operations will be deposited there for 25 years of mine operations. Much of the Lusala stream lies within the Mukulumpe farm and currently the stream is dammed on two points to store water for irrigation. The tailings dam will be located down stream from the irrigation dam before the confluence with the Mwambashi stream.

Figure 4.12 Selected site for tailings dam location on Lusala Stream downstream of the irrigation dam.

4.15.5.2 Water drainage and flood-prevention structure

The water drainage and flood prevention of this impoundment uses a concourse system, that is, the same system is used for water drainage and flood prevention. Considering the relatively flat topology of this reservoir and relatively higher tailing piling in the reservoir at the final stage, the water drainage flood prevention system which combines the water drainage well and drainage pipe is adopted, in which the water drainage pipe is used for drainage and the water drainage well is used for containing the water. Plans have been made to construct a frame type water drainage well of 15.0m height and 3.0m inner diameter, and a reinforced concrete water drainage pipeline of 90m length, 1.5m inner diameter, slope 2%, at downstream of the tailings impoundment. This pipeline will extend over the natural ground slope out of the impoundment. A spillway is to be constructed on the dam downstream the tailings impoundment. The inlet water in the spillway will be 13.5m high and 6.0m wide of a mortar-constructed stone structure, which will assist the water drainage well in discharging the flood water during the flood season.

In order to prevent embankment failure by overtopping due to storm rain water and to effectively discharge the penetrated water, a water drainage ditch is to be constructed on the outer side of the reservoir, slope 1.0%, trapezoid section, initial section depth 0.5m, width 0.5m and slope angle 45° at bottom, extending to the return water pool downstream.

4.15.5.3 Return water system

The tailings from the ore dressing plant, together with the water from the tailings impoundment will be clarified in the tailings impoundment. Part of the water will naturally be vaporized and part of will remain inside the tailings apertures in the impoundment. The bulk of the water in the tailings from the ore dressing plant will be reclaimed and sent back to the ore dressing plant as a supplement for process water.

To ensure the safety of the tailings dam and to enhance the management measures, specific management staff and maintenance personnel are to be assigned to the tailings dam to ensure close monitoring in every shift. Regular patrol inspections shall be carried out on the tailing dam. A guard room is to be set up near the tailings dam.

The tailings dam guard room will be supplied with power for lighting from the concentrator and telecommunication equipment which will be controlled by the concentrator. A land telephone will be installed in the guard room.

4.15.5.5 Management of the tailings dam

The tailings dam is the last work step in the course of mine production. It is a place used for environmental protection and a place where the tailings are piled orderly and safely. The production practice over a century has evidently proved the method of piling the tailings in a tailings dam used today in the production is a relatively mature and effective method. However in the whole mining industry, a few mining enterprises have encountered problems with their tailings dams, such as collapsing of the structures, blockages, landslides, dam failure and etc. These accidents are due to both subjective and objective causes. They have brought about serious economic losses and personal hazards to the residents and industrial enterprises in the area around the reservoir and in the downstream area of the reservoir. This has negatively affected the mining enterprise in terms of social benefit and economic benefit. Therefore the security of the tailings dam is the most important issue of the production management of the mine.

The hazardous accidents at tailings dams have mainly been attributed to the following causes:

Unstable dam slopes that have caused overall or local landslide resulting in water and sand discharge out of the impoundment

The insufficient discharging capacity of the drainage structure in the embankment has caused the water in the impoundment to overflow over the dam and consequent dam collapse

During the flood season, due to improper management, the arch cover in the drainage well is set at too high a position which has caused the water level in the impoundment to increase constantly. If this increase is not stopped the saturated water level in the dam body increases causing the penetrated water to overflow from the dam slopes resulting in damaging of the dam body by the penetrated water flow

Due to improper management, the tailings slurry is discharged along a line parallel with the dam axes causing too much water accumulation in front of the dam resulting in some parts of the dam body to begin to slide and to break.

To ensure the safety of the tailings dam and enhance the management measures, specific management staff and maintenance personnel will be assigned to the tailings dam to ensure constant monitoring in every shift. Regular

(9) Maintenance and management of the tailings transfer pipeline will be enhanced. In case of an accident the pipeline will be shutdown, cleaned and discharged to prevent tailings leakage due to blockages in the pipeline.

4.15.6 Water Requirements

Total water consumption in the mine: 38590.0 m^3/d

New water consumption in production: 13750.0m^3/d

Living water consumption: 840.0m^3/d

Water circulation volume: 15500.0m^3/d

Backwater volume: 8500.0m^3/d

4.15.7 Water resource

Process water as well as domestic water will be supplied from underground. The normal water discharge under the shaft of N1 ore body will be enough to meet the demands for process water and domestic water except drinking water which will be supplied in barrels from an out outside source. Water for fire prevention will also come from underground.

4.15.8 Chemicals and Reagents Associated with Chambishi South East Concentrator

Chemicals to be used at the concentrator will include collectors, frothers, flocculants and lime as listed in table 1.

Table 4.12. List of chemicals to be used by Chambishi South East Concentrator.

Name	Supplier	Country of Origin	Consumption	Use
Collectors (Xanthates)	Cytec Industries	UK	80-120g/t	Flotation
Frothers	Cytec Industries	UK	10-20g/t	Flotation
Flocculants	Cytec Industries	UK	10-20g/t	Settling aids
Lime	Ndola Lime Company	Zambia	5-10kg/t	Flotation

4.16.4 No Project Option

The no project option will result:

- No construction of the mine and leach plant
- No expenditure on construction of the plant
- No employment to the surrounding community during the construction and operation of the plant
- No disturbance to the land except what has already been cleared for exploration
- Loss of investment worth millions of dollars
- Loss of Tax revenue by Government
- Loss of Tax Revenue by Kalulushi Municipal Council

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
				plant and workshop equipment will be first priority	Manager		
		87	S	Noise reduction measures such as sound insulation and noise enclosure will be used in electric equipment.	Site Manager	2011	2016
		88	S	The main air blower room will be sound proof and will have sound proof walls to protect the employees from high noise levels,	Site Manager	2011	2016
		89	L	Planting trees along access and periphery roads shall shield and reduce noise levels.	Site Manager	2011	2016
Soil	To protect soil from contamination from fresh and used oil spills.	90	S	Refuelling of construction equipment will be done in designated areas and periodic maintenance will be done on all equipment to avoid oil leaks getting into the soil.	Site Manager	2011	2016
		91	S	Drip trays will be used in	Site	2011	2016

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
Surface Infrastructure – Preparation/ planning and Construction							
Air Quality	To prevent contamination of ambient air by dust.	78	S	Water bowsers will be used to spray access roads and all construction sites to suppress dust.	Site Manager	2011	2016
		79	S	If available molasses will be sprayed on roads and construction sites to suppress dust formation.	Site Manager	2011	2016
		80	L	Trees to be planted along the plant site periphery and access roads to act as wind breaker.	Site Manager	2011	2016
Surface Water Quality	To prevent surface water contamination	81	S	Storm water drains will be constructed around all infrastructures to be constructed. These storm water drains will prevent erosion of soil and run into the main storm water drain that will lead into a series of settling ponds.	Site Manager	2011	2016

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
	acceptable levels.			exceed 82 dB. Safety officers will monitor the use of ear protection on the mine.			
		125	L	Trees planted along access roads and the plant periphery will not only act as a wind breaker but also sound proof.	Manager Environment	2017	2040
Solid waste	Dispose solid waste accordingly	126	S	Waste coming from different sources will be segregated accordingly.	Manager Environment	2017	2040
		127	L	An area for solid waste segregation will be marked out and labelled according to kinds of waste to be placed in those areas.	Manager Environment	2017	2040
		128	L	In different places colour coded bins will be placed according to type of waste to put in those bins.	Manager Environment	2017	2040
	To put in place waste management procedure.	129	L	A waste management procedure to be put in place.	Manager Environment	2017	2040

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
		136	L	Warning signs to be written in symbols, English and Vernacular language.	Manager Security	2017	2040
	To minimise health and safety risks.	137	S	All employees shall undergo medical examinations once every year to ascertain their fitness.	Mine Manager	2017	2040
		138	S	A medical fitness certificate will be required before a person is engaged.	Mine Manager	2017	2040
		139	S	All plant equipment will be subject to a routine maintenance programme to ensure they are in good working order, hence minimising health and safety risks.	Workshops Manager	2017	2040
		140	S	All workers whether contractor or not will be subject to wearing appropriate personal protective equipment (PPE) depending on the work type and place.	All Managers	2017	2040
		141	S	All workers to go through safety	All Managers	2017	2040

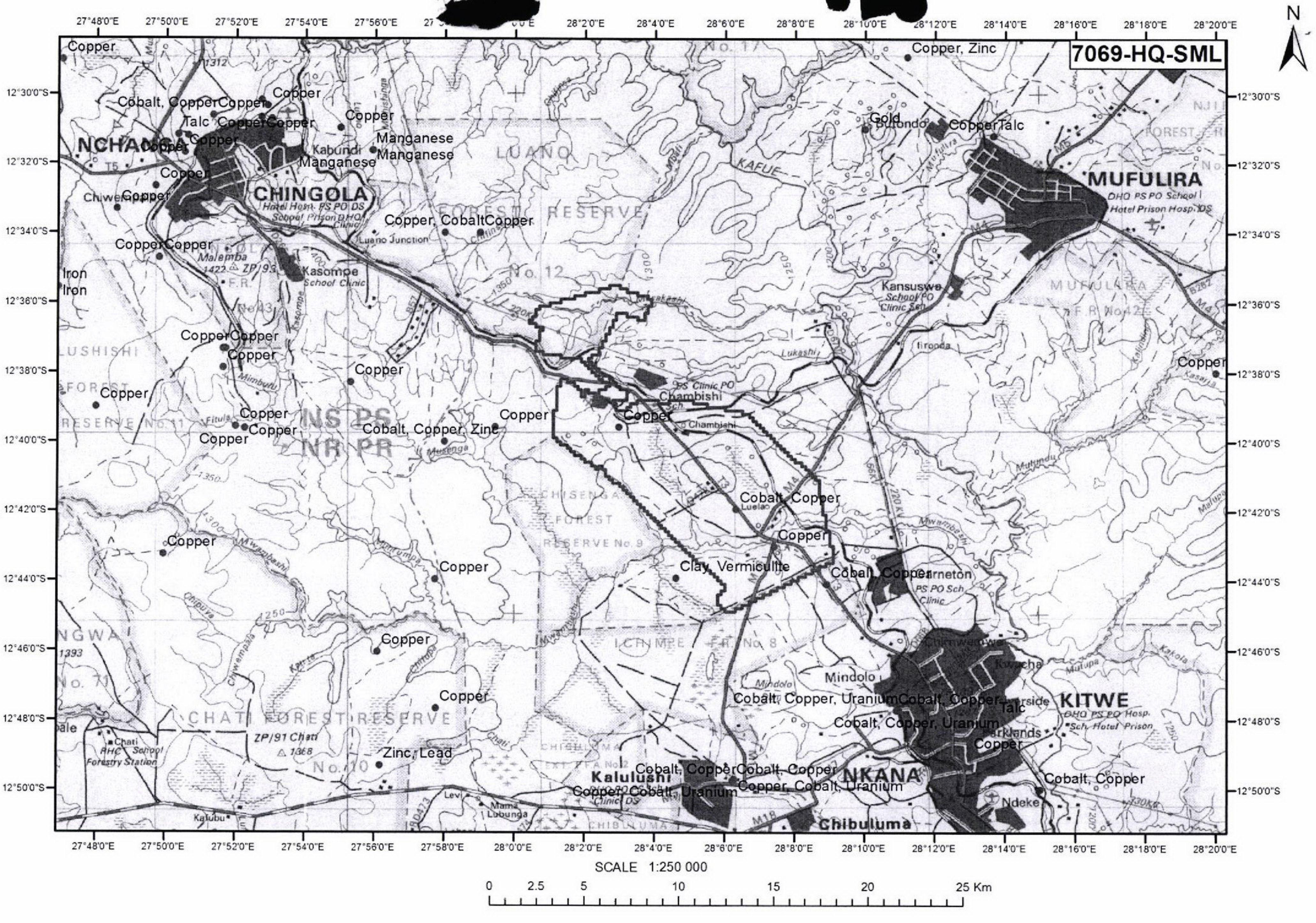
Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
Landscape and Visual Characteristics	To protect visual characteristics of the landscape.	148	L	Demolition of all surface infrastructure, grading and re-profiling of the surface and re-vegetation will change the landscape and visual characteristics.	Manager Environment	2041	2045
Land use	To rehabilitate the area	149	L	Demolition of all surface infrastructures, grading and re-profiling of the surface and re-vegetation.	Manager Environment	2041	2045
Soil, Surface and ground water	To abate effects of ARD on soil, surface and groundwater.	150	S	Determine ARD forming potential of the waste rock and tailings.	Manager Environment	2041	2045
Mining Methods – Preparation/ Planning and Construction Phase							
Air Quality	To prevent contamination of underground air	151	S	Water and air blasts to be used whenever blasting is being conducted.	Mine Manager	2011	2016

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
	and fumes from drilling, blasting and diesel units			wet drilling methods to avoid dust generation into the mine environment.	Manager		
		173	S	Diesel equipment to be equipped with gas absorbers	Mine Manager	2017	2040
		174	S	Use of low Sulphur content fuel will be prioritised	Mine Manager	2017	2040
		175	L	Ends shall be washed before lashing	Mine Manager	2017	2040
		176	L	Use of water blasts shall be prioritised	Mine Manager	2017	2040
		177	S	Ventilation section to monitor air quality underground according to schedule.	Mine Manager	2017	2040
Noise	To minimise noise levels to acceptable levels.	178	S	All mine equipment and machinery will be subject to a routine maintenance to ensure they are in good working order, hence minimising noise levels.	Mine Manager	2017	2040
		179	S	Only recommended and approved explosives shall be	Mine	2017	2040

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
				inductions	Manager		
	To quickly attend to accident victims	186	**VS**	An on site ambulance will be provided in case of any accident requiring transporting of the patient to the nearest hospital.	Mine Manager	2017	2040
Tailings	Use tailings to backfill stopes	187	S	Classified tailings to be used to fill the goabs underground	Mine Manager	2017	2040
Waste Rock	Use waste rock to backfill stopes	188	S	Part of the waste rock shall be used to fill the mined out stopes	Mine Manager	2017	2040
Mining Methods – Closure/ Decommissioning Phase							
Caving	To prevent caving and cracking of the surface and surface infrastructure	189	VS	The mined out voids (goabs) will be filled (backfilled) with a mixture of waste rock and classified tailings and cement.	Mine Manager	2017	2040
		190	VS	Chain and rib pillars will be left between and within stopes minimise the height and width of failure.	Mine Manager	2017	2040

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
				levels.			
	To protect workers from noise exceeding acceptable levels.	164	VS	Employees will wear appropriate ear protection in workplaces where noise levels exceed 82 dB. Safety officers will monitor the use of ear protection on the mine.	Mine Manager	2011	2016
Mining Methods – Operational Phase							
Caving	To prevent caving and cracking of the surface and surface infrastructure	165	S	The mined out voids (goabs) will be filled (backfilled) with a mixture of waste rock and classified tailings and cement. Only 4.06 m of caving will occur with backfilling in place.	Mine Manager	2017	2040
		166	S	Chain and rib pillars will be left between and within stopes minimise the height and width of failure.	Mine Manager	2017	2040
		167	S	Relocation of the farming community directly sited on top	Chief Executive	2011	2016

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
		152	S	Road ways to be water sprayed regularly	Mine Manager	2011	2016
	To monitor the air quality underground	153	S	Ventilation section shall take routine measurements to measure the levels of particulate matter, gases and fumes underground.	Mine Manager	2011	2016
Accidents	To prevent injury to workers	154	S	Workers shall wear recommended and appropriate personal protective equipment depending where they are working.	Mine Manager	2011	2016
		155	S	All works shall have proper established, documented and approved procedures.	Mine Manager	2011	2016
		156	S	Entrances to tips, stopes and any place that is dangerous shall be barricaded accordingly.	Mine Manager	2011	2016
Vibrations	To minimise vibrations and consequently cracking of surface infrastructure such as	157	S	Only recommended and approved explosives shall be used at the mine.	Mine Manager	2011	2016



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Kansuswe
Garneton
Mindolo
Chimwemwe
Kwacha
Parklands
Ndeke
Luano Junction
Kabundi
Butondo
LUANO FOREST RESERVE No. 12
MUFULIRA F.R. No. 42
CHISENGA FOREST RESERVE No. 9
ICHIMPE F.R. No. 8
CHATI FOREST RESERVE No. 10
Copper
Cobalt, Copper
Talc
Manganese
Copper, Cobalt
Copper, Zinc
Gold
Iron
Cobalt, Copper, Zinc
Clay, Vermiculite
Cobalt, Copper, Uranium
Copper, Cobalt, Uranium
Zinc, Lead
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Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
				excess into the surface water.			
Noise	To minimise noise levels to acceptable levels.	50	S	All mine equipment and machinery will be subject to a routine maintenance to ensure they are in good working order, hence minimising noise levels.	Mine Manager	2017	2040
		51	S	Only recommended and approved explosives shall be used in the blasting operations.	Mine Manager	2017	2040
		52	S	Blasting will be conducted according to the blasting schedule to restrict noise pollution to specified times.	Mine Manager	2017	2040
	To protect workers from noise exceeding acceptable levels.	53	VS	Employees shall wear ear muffs or ear plugs and other necessary Personal Protective Equipment.	Mine Manager	2017	2040
		54	VS	Selection of low noise level equipment when purchasing equipment will be first priority	Mine Manager	2017	2040
Vibrations	Reduce vibrations	55	VS	Blasting will be conducted	Mine	2017	2040

Table 6.1 Environmental Management Plans for the South East Ore body Project

Environmental Aspect	Objective	Item no.	Rating	Environmental Management	Responsible Person	Timing	
						Start	End
Shafts - Preparation/ Planning and Construction Phase							
Surface Water Quality	To prevent surface water contamination	1	L	Sedimentation pond will be dug just beside the shaft to store the wastewater and solids will be settled to the bottom while the clear water is re-used in the drilling process.	Site Manager	2011	2016
Noise	To minimise noise levels to acceptable levels.	2	S	All plant will be subject to a routine maintenance to ensure they are in good working order, hence minimising noise levels.	Site Manager	2011	2016
		3	S	Only recommended and approved explosives shall be used in the blasting of shaft sinking process.	Site Manager	2011	2016
		4	S	Blasting will be conducted according to the blasting	Site Manager	2011	2016