Federal Democratic Republic of Ethiopia

Environmental Protection Authority

Environmental Impact Assessment Guideline

For

Mineral and Petroleum Operation Projects

NOT FOR CITATION

This guidelines is still under development and shall be binding after consensus is reached between the Environmental Protection Authority and the Environmental Units of Competent Sectoral Agencies

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Table of Content

GLOSSARY

Acid mine drainage All sources of acid water in a mining operation, i.e. oxidation of sulphidic mine waste, typically occurring as a runoff or seepage from waste rock stock piles, tailings impoundments or coal rejects

Adit A horizontal underground passage directly connected to the surface and intended to serve as a passage for underground mine.

Aquifer Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantity of water to wells and springs.

Artisanal mining Any operation which consists extracting and concentrating mineral substance to obtain marketable product by using traditional or manual methods and procedures

Base metals Base metals considered to be copper, lead or zinc, tin, zinc, mercury, and antimony

Baseline information Monitoring data acquired prior to the beginning of a project such as mining. This provides a basis for comparison and identification of charges caused by the mining process

Catchments (drainage) The land area from which surface runoff drains into a stream (river) system

Coal is a source of energy formed largely by burial of forest and swamp type of vegetation under high pressure and temperature.

Closure The act of closing or the condition of a mine being closed

Effluent Any waste product, whether treated or not, from an industrial process, or other human activities, that is discharged into the environment

Environmental impact Any change to the environment, either beneficial or adverse, wholly or partly resulting from an organization's activities, products or services

Exploration Exploration includes all activities involved in the discovery and evaluation of mineral deposit

Flora All plant life in a region

Heap leach To dissolve minerals or metals out of an ore heap using chemicals

Hydrocarbon Chemical compounds whose molecules are composed of atoms of solely two elements, carbon and hydrogen, whose combustion reaction produce a very large amount of energy.

Industrial minerals and rocks Minerals and rocks of economic value, exclusive of metallic minerals, fossil fuels and gemstones, comprises of construction and non-construction materials, such as aggregates, cement making materials, building and dimension stone and ceramics and refractory, abrasives, fillers , etc.

Leachates Solutions of chemicals leached out by water percolating through waste landfill, overburden dumps, soil stockpile or contaminated undisturbed ground such as that around underground storage tanks.

Mining Extraction of ore from the ground

Mineral development Establishment of the entire infrastructure of a mine site

Mineral or petroleum Operation All activities involved in the exploration and development of mineral and petroleum reserves. The operation includes office planning and preparation, field work such as exploration, infrastructure construction, mining (extraction of mineral or petroleum), refining and marketing of mineral or petroleum resource

Mineral processing (ore dressing) Milling of the ore, separation of ore minerals from gangues, separation of the ore minerals into concentrate

Oil shale compact mudstone and clay sedimentary rock consisting of organic matter which yields oil and gas when heated in oxygen less environment

Open pit mining Is defined as the mining of ores by surface mining methods where waste or overburden is first removed and the mineral is broken and loaded

Operator/ owner or proponent An individual or a company that has ownership and/ or control of a mineral / petroleum property either through lease of mining claims or other type of ownership

Ore Economic metallic mineral deposits, industrial mineral deposits, and energy mineral deposits

Overburden Unconsolidated material that must be removed from its original place to expose the bedrock or ore body. It consists of topsoil and subsoil.

Petroleum Liquid substance composed principally of hydrocarbons which occur in underground natural reservoirs

Pollutant Any solid, liquid or gas or combination including waste smokes, dust, fumes and odour or noise, heat or anything declared by regulation to be a pollutant

Pollution To make unclear, impure, or corrupt; desecrate; defile; contaminate; dirty or usually implies unnatural circumstances either physically, chemically, or biologically impure that adversely or unreasonably impairs the existing quality of the environment

Precious metals Metals of gold, silver and platinum groups

Prospecting Part of exploration, which deals with direct looking for indications of ore mineralization in outcrops in sediments and soils

Quarry Open or surface working areas usually used for the extraction of construction materials, such as building stones,

Reclamation The process of returning a disturbed area to its natural state, or to a state suitable for equivalent or superior use or benefit

Rehabilitation Restoration work done during or at the end of a mining project which reduces the physical, and chemical hazards on site, and which may also improve visual aesthetics and the potential for some other beneficial use of the land to the original or equally satisfactory condition.

Rock waste Rock materials of no economic value other than overburden that must be removed to excavate the ore

Sealing The securing of mine entries, drifts, adits, slopes, shafts, and boreholes with suitable materials to protect against fire, gas, and water emissions and for the safety of the public

Shaft A vertical opening used as a passage directly with underground mining area

Smelting Recovering metals from mineral concentrates

Soil The upper portion of the earth's layer that has been weathered by environmental factors

Subsidence Gradual sinking of landform to a lower level as a result of earth movement and mining operations

Surface mining Strip mining and open pit mining. Strip mining consists of stripping away layers of soil and waste rocks over a mineral deposit often found in relatively horizontal geological layers. Open pit mining involves excavating the earth's surface in a concentrated location to access the underlying mineral ore body.

Tailings Materials rejected from a mill after the recoverable minerals have been extracted or Waste products arising from the grinding and treatment of rocks with chemicals to extract desired minerals

Toxic Inorganic and organic chemicals even in extremely low concentrations may kill organisms or reduce their growth

Undergrounds mining (subsurface mining) The ore extracted below ground by digging shafts and adits as a passage to the underground and for ventilation

Waste Any solid, liquid or gas or combination that is left over, surplus or is unwanted byproduct from any business or domestic activities or substance or mixture of substance which has no current economic use

Water balance Calculation of all water gains and losses related to an operations such as mine sites

1 INTRODUCTION

Mines and petroleum production bring prosperity to a country, in particular, to the area in which they are established. One mine creates about three direct jobs: 1, directly for the community, 2, for service giving organizations, and, 3, for construction industries. It can also create indirect jobs for financial institutions and others. However, mines and petroleum production activities are bound to have environmental impacts.

The technological development today, starting from the house utensils, electrical wires, cars, building and road construction, space shuttles, medicines need mineral products. The world demand for minerals will continue to increase and the world will continue to deplete minerals. To balance the impacts of mining and petroleum productions on environment and the demand for mineral, designing tools that can help for a safe and sustainable utilization of the mineral resources is needed. One of the tools used for safe and sustainable development of mineral resources is exercising environmental impact assessment guidelines. To protect the environment from serious impacts that might arise from any mining operation preparation of this guideline has become necessary. This guideline has summarized:

- Background/ or chronological development of the mining industry of Ethiopia briefly, i.e.
  - The exploration history and the development towards modern mine opening and artisanal mines and their effect on the environment.
  - In Ethiopia the artisanal mines tend to do more damage to the environment with greater cost per unit of out put than modern mining. For this reason a special attention is given to the environmental impact and mitigation measures of artisanal mine,
  - A review of petroleum and mineral operation laws relevant to the environment and the Environmental Policy of Ethiopia,
- The activities involved in minerals and hydrocarbon exploration, exploitation, refining and marketing. This part of the guideline has covered the exploration phases which includes the preliminary, advanced and deposit evaluation, and development of mine (infrastructure development), production (mine), closure and post closure fellow up,
- The impacts of exploration, surface and subsurface mining, mineral processing and marketing on the environment and suggested mitigation measures and environmental planning are stated in every corresponding sections .
- Air, water and soil quality standards and checklist are included in the appendices.

The guideline is organized in such away that the impact of exploration is considered first, development phase and mining phases separately with transfer of environmental information from the preceding phase of operation (activities) to the next phase. The preceding environmental study is a base to the following phase of activity. The environmental impacts of mines and petroleum operations are related with the activities of airborne geophysics, regional geological survey, ground geophysics and geochemistry survey, stripping and trenching, sampling and assaying, drilling, infrastructure development, mine plant construction, mine mills, smelting, tailing and waste rock deposit, and marketing. Preliminary environmental study (base line survey) during the early exploration, and full scale environmental impact assessment study during an advanced exploration phase (underground shaft opening and bulk sampling of several hundred tones of ore), development and production stage is necessary. in order to suppress the environmental impact, taking mitigation measures and progressive rehabilitation during operation and rehabilitation during decommissioning and monitoring after closure are recommended.

Guidelines for environmental impact assessment can vary depending up on the type of minerals to be explored and mined and method of mining, the law and regulations of the Federal and Regional States, the size and location of the mine, type of support facilities (technology), the environmental resources that will be affected and other factors.

Therefore, This guideline is not intending to be an exhaustive guide for environmental impact assessment study of every mineral and petroleum operation projects. Rather it is a document containing sufficient information relevant to environment protection measures to be taken by operators engaged in mineral and petroleum exploration, regulatory bodies, interested groups and the public who seek a generalized guideline to undertake an overall environmental impact study that should be incorporated in report of mineral operations.

The need of high level national commitment to a clean and healthier environment is growing all over the world. The ultimate responsibilities for the protection of the quality of our environment should be a cooperative endeavor to be shared by Government, private enterprise, and by the individual citizen. Among these groups the mining and petroleum community should take their share of responsibility to protect the quality of our environment.

The exercising of this guideline by the operators and others will be best when used in conjunction with the procedural and review guidelines. This guideline document may require updating in a course of time as more practical experience is achieved.

1.1 OBJECTIVES OF THE GUIDELINE

Environmental Protection Authority (EPA) is in charge of the environmental protection and sustainable use of natural resources. This can be exercised by controlling the implementation of environmental planes of development projects. In order to achieve EPA its objectives introduction and exercising of various tools and guidelines in various development sectors and regulatory units are necessary. In light of this an attempt has been made to prepare environmental impact assessment guideline for the mineral and petroleum operation projects in Ethiopia.

The specific objectives of this environmental impact assessments guideline is to establish a system and provide guidance that enable to the operators engaged in mineral and petroleum operations and other concerned parties to bring the impacts and mitigation measures into focus at such an early stage in the planning process that those impacts may either be mitigated or avoided by means of:

- Modify and improve design,
- Better way of mining,
- Ensure efficient of resource use,,
- Enhance environment and social benefits,
- Avoid, minimize or remedy adverse impact,
- Identify key impacts and measures for mitigating them,
- Avoid serious and irreversible damage to the environment,
- Protect human health and safety,
- Ensure that residual impacts are within acceptable level,

1.2 OVERVIEW OF THE MINING INDUSTRY AND MINES LEGAL FRAMEWORKS IN ETHIOPIA

The modern mineral exploration commenced in 1867 by Blanfor, British Geologist. Since then the exploration activities were on and off. During the Italian occupation of Ethiopia, exploration for minerals accelerated significantly than ever before. To day the exploration for minerals is progressing with the assistance of modern technology. The establishment of Geological Survey of Ethiopia accelerated further the exploration activities.

However, the discovery of economic mineral deposits were limited to the Adola Gold deposit and other few industrial minerals (soda ash, rock salt, potash, ceramics, etc) and construction materials (cement raw materials, dimension stones such as marble, granite, etc.). At present the mining industry (extraction of minerals) in Ethiopia is not very important in terms of its distribution, size, and its economic contribution.

According to reports released by the Ministry of Mines and other published studies more than 500,000 people are engaged in traditional construction material production and gold mining along several river banks and residue soil developed on primary gold deposits.

Extraction of industrial minerals and rocks and the artisanal mining activities for gold have already been reported to have caused environmental impacts, i.e, human death, erosion of arable land, etc.. The traditional miners at place use mercury, and remove plants which can cause change to the environment due to soil destruction, chemicalization of soil and water.

In the Ethiopian case the environmental problem associated with the traditional mining activities is more sever than in the modern mines which have legal entities. The traditional miners have not fulfilled legal requirements, no control of gold trade, mining planning, safety procedure, no documentation, poor sanitation condition, and no proper medical services. All those problems can cause environmental and social problems.

Digging, creating embankments, clearing shrubs, and trees contribute to the degradation of arable land. Dust produced by crushing, digging, sluicing can cause eye troubles, skin diseases, respiratory infections, and security problem, child labor, child prostitution are also problems associated with artisanal mining.

1.3 POLICY AND LEGAL REQUIREMENTS

The environmental policy, mineral and petroleum operation laws are some of the tools introduced in order to safeguard the environment form impacts related to these area.

1.4 REQUIREMENTS OF THE ETHIOPIAN ENVIRONMENTAL POLICY

The Environmental Policy of Ethiopia (1997), with regard to the minerals and energy (fossil fuel or petroleum and coal) development and use impact on the environment are spinning around the following points.

- Long-term usability of land be safeguarded;
- Promote environmental protection, safe mining method and reclamation of abandoned mining area;
- Establish a guarantee for the restoration of the land to its previous conditions;
- Promote development and sustainable utilization of renewable energy resources;
- Reduce use of fossil energy;
- Energy conservation;

1.5 CATEGORIES OF THE MINING LICENSES IN ETHIOPIA

The mining proclamation No. 52/1993, part I, article 2(9) has classified the mine licenses for mineral operations into three license ranks:

- Prospecting license;
- Exploration license, and
- Mine for minerals (exploitation) license.

The license for mine for minerals in Ethiopia is subdivided further into:

1. Artisanal mining;
2. Small scale mining; and

3. Large scale mining.

1.6 REQUIREMENTS OF THE MINING AND PETROLEUM OPERATION LAWS

The proclamation No. 52/1993, mentioned above has provided different degree of right to the various licensees to use the natural resources, such as:

- Construction minerals and rocks, water and timber is allowed, but is restricted not to use surface water if such use of water results in substantial reduction for other users or if it results in pollution. Dam construction and river diversion also need prior approval by concerned authority;
- If displacement of the occupants is required the licensee should negotiate with the occupant for compensation payment or the Government intervenes and settle the dispute between the occupant and licensee;

- Construct infrastructure necessary for operations, communications, roads, power, industrial, administrative, residential, medical and other buildings necessary for mining operations is permitted on temporary bases for prospecting, exploration and artisanal mining operators. All construction of permanent nature can be removed by the licensee or abandoned and become Government property;

- The Petroleum Operations Proclamation No.295 of 1986 has stated areas precluded from petroleum operations; such as anthropological, archaeological, and historical objects and sites; prevent damage to subsurface formations and ensure petroleum, mud or any other fluids of substance do not waste or escape from the hole to surface,
- If the Ministry of Mines thinks that the petroleum operations may endanger persons or property, harm natural resources or the general environment, can order to discontinue the operations. Environmental considerations with regard to the petroleum operations mainly focuses on exploration boreholes and their surroundings. It has not considered the environmental damage that might occur during the pre-drilling exploration activities and during production.

1.7 THE SCOPE OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

EIA study of mineral and petroleum operations considers how the exploration, development, processing and marketing of minerals will affect the:

- Local human population,
- Local and regional wildlife population,

- Local land use and overall ecology,

- Change to land and water regimes and land contours,

- The disposal of mine waste and tailings, together with other issues such as transportation of product to market all have to be evaluated.

The consequences of mineral, and hydrocarbon resource exploration and development on the environment is enormous and complex. Therefore, EIA study should be conducted by a team composed of:

- Subject area expert (environmental geologist),
- Pollution control,
- Land use,
- Socio-economist,
- Ecologist, and
- Environmental health experts.

Mineral and petroleum operation are projects of many stages. The collection of data for environmental impact assessment for mineral and petroleum operations should be made as part of this process. The environmental impact assessment study in mineral and petroleum operations should be separated into two categories. One is for operation that might terminate in the exploration stage, and the second for operations that might intend to a development and mine minerals and petroleum production. Basic base line data information needed include:

- Geological, hydrogeological, botanical, zoological, archaeological, historical, cultural, sociological, and economic,
- The existing land use,
- The relative abundance, quality and regenerative capacity of natural resources in the area,
- The absorption capacity of the natural environment
- Trans-boundary impact and complexity,
- Provide basic information for assessing any changes,
- Set the initial level of element concentrations of surficial materials to be monitored in monitoring programs,

2 ENVIRONMENTAL IMPACTS AND MITIGATION CONSIDERATIONS

The purpose of mitigation is:

- Find better way of developing mineral and petroleum resources,
- Enhance environmental and social benefits,
- Avoid, minimize or remedy adverse impacts,
- Ensure that residual impacts are within acceptable limit,

2.1 Exploration

The exploration for minerals has two stages:

- Surface exploration, and
- Subsurface exploration.

2.1.1 SURFACE EXPLORATION

Airborne and ground-based geochemical, and geophysical surveys, line cutting, stripping, and trenching, road/trail building and or helicopter transport, bulk sampling are the main activities of exploration.

2.1.2 ENVIRONMENTAL IMPACTS:

Environmental impacts of surface exploration are:

- Trail/road and trenching related erosion
  - Tree clearing during construction of paths of field trucks,
  - Seismic lines, and aircraft strips,
- Habitat disruption;
- Noise pollution,
- Landscape distraction
  - Digging, trenching and excavation, quarrying, and use of explosives
- Camp garbage;
- Dissemination of diseases in the human, animal or vegetation populations with the moving vehicles and workers;
- Camp sites impact due to production of waste, used engine oil, packing garbage

2.1.3 MITIGATION OF SURFACE EXPLORATION IMPACT

- Up grade and use existing tracks and roads;
- Refilling pits and trenches to their initial situation.
- Minimize vegetation clearing along seismic lines
  - By curving survey profiles around prominent trees,
  - Using explosives instead of vibrosis,
  - Limiting the radius of explosive effect on aquifers,
- Minimizing clearing trees at comp sites

3 SUBSURFACE EXPLORATION

The surface exploration is followed by subsurface exploration The subsurface exploration can cause diverse effects both on the surface and subsurface environments. The environmental issues, impacts and mitigation indicated above for surface exploration can also work for the early stage of subsurface exploration.

3.1 THE MAJOR IMPACTS OF SUBSURFACE EXPLORATION

- Tree clearing
  - At well sits,
  - Camp sits,
  - All the way along the access, and
  - Seismic and other geophysical profiles;
- Increase in traffic density;
- Disturbance of subsurface formations;
- Introduction of drilling fluids, drilling chemicals, surface water and drilling oils to subsurface environment, such as;
  - Salt saturated fluid,
  - Oil-based fluid;
  - Gas-based fluid;
  - Reagents such a sodium acid pyrophosphate, sodium tetra phosphate, lignite, tannin, low viscosity carbo-xynethyle, etc.
  - Draining of chemicals used for sample analysis at well site, such as HCl, HNO_3, $K_3Fe(CN)_6$;
- Morphological leveling (alteration) along the access;
- Various level aquifer water mixing;
- The production of camp waste, used engine oils, shipping garbage;
- The risk of accidents (mechanical, electrical, blasting, etc);
- Change of the existing land use (if drilling site lays on farm land);
- Causing social disorder (change of social structure and customs, displacement);
- The excavation of exploratory shafts, Adits or declines,
- The digging of test pits and trenches, and the associated removal of material for bulk testing.
- The installation of a portable pilot plant or other temporary facility for subsurface ore and rock testing purposes, or any other significant ground disturbance conducted to determine the existence of a commercially exploitable mineral deposit can destroy natural setup of rocks and can trigger artificial discontinuity on the rocks ,

3.1.2 *MITIGATION MEASURES FOR IMPACTS OF SUBSURFACE EXPLORATION*

- Minimize noise and dust when working near residential areas;
  - Decrease the number of vehicles,
  - Regular servicing vehicles,
  - Control noise sources,
  - Use good blast design.
- Keep site clean and tidy
  - Remove all rubbish;
  - Remove all equipment and litter from the site;
- Identify any rare or endangered species and ensure their protection;
- Avoid spreading any plant or animal disease or noxious weeds;
- Use existing tracks wherever possible and keep clearing to an absolute minimum;
- Design new tracks to go around significant trees and roll vegetation, where necessary, so as to maintain topsoil and root systems;
- Avoid environmentally sensitive locations such as creek banks and areas subject to erosion;
- All fuel, and chemicals should be stored properly to avoid contamination of water or land;
- Ensure saline or contaminated water and drill fluids are not discharged into the surrounding environment via sumps, controlled drainage etc;
- Drill holes should be capped, permanently plug or seal or filled in (grouted), excavations back filled or fenced if they are to be left open and markers removed;
- Avoid unnecessary disturbance to surface soil to prevent erosion and retain as much vegetation as possible; stabilize surface, if possible,
- Surface re-contouring or diversion to establish drainage pattern
- Minimize risk of fire;
- Where vegetation has to be cleared, stockpile the topsoil (separately from the subsoil) and replace on disturbed areas (seeded or fertilized if required);
- Disturbed areas should be ripped to facilitate re-vegetation. The uneven surface will retain moisture from rainfall and windblown plant seed;
- Arrangements should be made for periodic monitoring and assessment of remedial action;

4 MITIGATION,COMPENSATION AND REABILITATION COST CONSIDERATIONS

Mining and petroleum operation environmental impacts mitigation and rehabilitation and associated costs occur throughout the cycle of exploration, development, mineral extraction, beneficiation, processing petroleum production, and transportation. The feasibility study of projects should consider and integrate the environmental cost of the project.

Direct environmental costs

- Assessment cost;
- Base-line study cost,
- Environmental impact analyses and report preparation cost;
- Prevention cost, such as tailing dams construction;
- Mitigation cost such as gaseous emission control and effluent/discharge control cost;
- Closure and reclamation cost;
- Waste disposal and contaminant control;

- Waste and disposal stabilization,
- Backfill of previous mined-out openings;
- Compensation cost to affected parties or for irrecoverable damage to the environment;
- Indirect environmental cost, such as telephone, electrical, transportation cost,
- Management cost such as
- Monitoring, stuff salary, training, etc should be taken into consideration during the financial analysis of the project.

4.1 MINE DEVELOPMENT (ESTABLISHMENT OF INFRASTRUCTURE)

The activities involved in mine infrastructure development are:

- Site preparation for mining
    - Removing vegetation
    - Leveling, cut and fill operations, excavating,
    - Quarry opening and the like

4.1.1 IMPACTS OF MINE DEVELOPMENT

- Evapo-transpiration regime imbalance,
- Excessive erosion,
- Quarries can result in ponds, ragged topography, etc,
- Slope instability,
- Change in stream flow rate patterns,
- Increase turbidity of streams and lakes
- Stream sedimentation;
    - Degradation of stream and river beds resulting from road building and drainage change;
    - Obstruction of fish reproduction;
- Dust problems,
- Habitat fragmentation i.e. roads disrupt:
    - Calving/rearing grounds,
    - Key forage areas,
    - Movement and migratory routes

- Increased wildlife mortality;
- Collision between vehicles and wildlife;
- Uncontrolled hunting, poaching;

- Pollutants in pristine areas;
- Chemicalization of soil:
  - Gas, oil, drill-core slurry, ground core assay chemicals;
  - Abandoned structures;
  - Garbage and noise;

4.1.2 QUARRIES

Quarries are opened for production of construction material such as selected materials for roads construction, dimension stones for buildings, gravel and aggregates, and ceramic and cement raw materials, etc.

Activities undertaking in quarry development are:

- Drilling
- Overburden removal (disposal)
- Plant site excavation,
- Quarry development,
- Blasting,
- Road and access construction,
- Formation of vertical cliff,
- Development of ponds,
- Erection of plant and ancillary structures
- Landform (ragged topography) creation,
- Accumulation sites of huge dirt
- Mass wasting (erosion)

4.1.3 Impacts of quarry site

- Ponds developed in a quarry can serve as breeding ground for water born disease and mosquitoes,
- Children who swim in quarry ponds could draw down and die and can be a threat to animals,
- The vertical cliffs can cause death to animals and human live,

- Land slide and land fall,
- Production of dust,
- Overburden disposal accumulation,
- Affecting farm land or cause land use change,

4.1.4 Mitigation

- Restoration of the completed overburden disposal areas
- Should be cultivated and seeded and tree planted,
- Adopt the safest quarry opening method,
- Eliminate hazardous high walls
- Shooting down the high walls
- Cover by soil and re-vegetation
- Establish appropriate quarry drainage system,
- Rehabilitate quarries and refill irregular and level surfaces around quarry sites,
- Re-vegetate abandoned quarry sites

5 MINING (EXTRACTION OF MINERALS) AND MINERAL PROCESSING (SEPARATION OF ORE MINERALS FROM GANGUE),

A mine site is place of activities of:

- Digging,
- Transportation (barges/air access routes),
- Energy infrastructures (power lines) tailings pond, waste rock piles, and processing plants construction,
- Stripping/storing of overburden of soil, ore extraction, crushing/grinding of ore, flotation or chemical concentration of ore, mine and surface water treatment,
- Storage of waste rock and tailings.

Acid drainage does occur when sulfide minerals are exposed to weathering and react with water and oxygen to produce acidic solutions, such as sulfuric acid. The acid leaches release heavy metals such as The mining toxic pollutants include the following:

- Antimony and compounds;
- Arsenic and compounds;
- Asbestos;
- Beryllium and compounds;
- Cadmium and compounds;

- Chromium and compounds;
- Copper and compounds;
- Lead and compounds;
- Mercury and compounds;
- Nickel and compounds;
- Selenium and compounds;
- Silver and compounds;

lead, zinc, copper, arsenic, selenium, mercury and cadmium are the elements known as heavy metal.

5.1 MINE CLASSIFICATION

Following the surface and subsurface exploration, if the feasibility study proves the mineral deposit to be commercial, the whole operation transforms from exploration to extraction of minerals. Mines are classified in to:

- Surface mine;
- Subsurface mine.

5.1.1 SURFACE MINING:

- Artisanal mining
- Open pit mining ,
- In bench or steps,
- Overburden removed by stripping,
  - Quarrying (dimension stone),
  - Open cast or strip mining, overburden removed,
  - Auger mining,
  - Aqueous extraction (placer mining and solution mining).

5.1.2 IMPACT OF SURFACE MINING

5.1.3 Impact of artisanal mining

Artisanal miners and small scale miners tend to do more damage to the environment than those workin

- Digging and creating:

- Embankments,
- Trenches
- Excavated pits,
- Land slides,
- Tailing pile in river beds,
- Deforestation,
- Dust production,
- Waste mineral resources,
- River siltation,
- Hazardous to death,
  - Exposure to dust
  - Exposure to chemicals, heat, lack of oxygen,

- Erosion damage,
- Social unrest,
- Effect on the ecosystem,

5.1.4 Mitigation measures of artisanal mining impact

- Establishing legal and institutional conditions,
- Provision of technical assistance,
- Introduce mining extension services,
- Establish authority structure in the mining site,
- Establishment of incentive scheme to reduce damage on environment,
  - Providing picks, sluice boxes, etc.
- Promotion of artisanal miners to small scale mine cooperatives.

5.1.5 Impact of large scale surface mining

Impacts on physical stability

- Destruction and disruption of vegetation;
- Removal of top soils,
- Disruption of natural drainage pattern and land use;

Impacts of chemicalization (acide mine drainage)

- Erosion of cleared areas and soil overburden dumps leading to sedimentation and pollution of water courses due to;
    - Imbalance of acidity and alkalinity
    - Heavy metals from tailings and process chemicals
    - Suspended solids (turbidity) due to:
        - inadequate setting in tailings pond
        - wave action on tailings pond
        - high runoff over un vegetated loose material

Dust created during operations creating visibility problems and loss of agricultural production;

- Water consumption effect;
- Visual impacts,
- Modification of land forms,
- Noise and vibration effect from machinery;
- Blast effects;
- Silicosis and other respiratory problems.

5.1.6 MITIGATION MEASURES OF LARGE SCALE SURFACE MINING IMPACTS

- Restore the land to a condition capable of supporting pre-mining uses or higher or better uses;
    - Stabilize slopes by
        - Flattening slopes
        - Construct toe berm
        - Establish vegetation or place riprap,
        - Provide stable spillway and overflow
- Restore the approximate original contour of the land;
- stabilize surface areas and spoil piles to control erosion and air and water pollution;
    - Develop a top soil management,
    - Reuse topsoil in rehabilitation program,
    - Control reactions,
    - Control chemical migration,

    - Collect and treat,

- Remove, segregate, protect, and replace topsoil or other strata shown to be more suitable for supporting vegetation;

- Utilize special handling for the various soil horizons present in prime farmland

- Create appropriate water impoundments that are stable and that protect water quality;

- Seal auger holes to protect drainage;

- Minimize disturbance to the prevailing hydrologic balance on and off the mine site;

- Construct stable and re-vegetated surface disposal areas for mine wastes, and tailings;

- Treat, bury, or dispose of acid-forming, toxic, or combustible waste materials to prevent water contamination;

  - Control acid drainage and or leaching of metals or contaminants

  - Underwater disposal to control reactions

  - Pre-treatment-blending of alkaline material to mitigate acid drainage

  - Detoxify by flushing with water or with lime solution

- Use explosives in accordance with existing federal and regional laws ;

- Construct and maintain access roads so that erosion, siltation, water pollution, damage to fish and wild life or their habitat, or damage to public or private property will be prevented;

- Upgrade and use existing roads,

- Reduce road congestion.

- Refrain from road construction that will seriously alter the flow of streams or drainage channels;

- Re-vegetate disturbed lands with diverse, effective, and permanent species native to the area;

- Protect off site areas from slides or damage occurring during the mining and reclamation operations;

- Place excess spoil material in such a manner to assure stability and proper drainage and prevent erosion;

- Use the best technology currently available to minimize disturbance and adverse impacts on fish, wildlife, and environmental values;

- Progressive backfilling to minimize land disturbance;

- Minimize dust migration

- Use dust control equipments like covers or control devices for crushing and milling to avoid the generation of dust; watering for dusty roads,
- Minimize area of stripping,
- Rehabilitate mined area as soon as possible,
- Consider using binders on haul roads

➢ Minimization of acid mine drainage generation;

- Diversion of leachates from waste heaps to avoid contact with and contamination of surface water and groundwater;
- Use sedimentation ponds,
- Harvesting water,
- Minimization of fresh water intake;
- Use of ditches to divert surface runoff from tailing ponds;
- Collection and recycling of waste oils and lubricants;

➢ Prevention of spills of chemicals;

- Packaging as required and labeling in languages necessary to identify the material
- Task and safety training for transporters
- Provision of appropriate storage area for chemicals and fuels,
- Avoidance of the use of toxic floatation agents;

➢ Control of noise:

- Through the use of berms and mufflers,
- Use good blast design,

5.2 SUBSURFACE MINING:

- Self-supported;
  - Room and pillar mining;
  - Stop and pillar mining;
  - Shrinkage stopping;
  - Sublevel stopping;
  - Vertical crater retreated mining;
- Supported mining;

- Sut and fill stopping,
- Stull stopping,

- Caving method;
    - Long wall mining;
    - Mublevel caving;
    - Block caving;
- Novel mining
    - Rapid excavation;
    - Hydraulic mining;
    - Methane drainage;
    - Subsurface gasification, etc
    - deplete high-grade shallow minerals,
    - deplete deeper low-grade deposits;
    - interdisciplinary approach in planning and in decision making;
    - develop methods that ensure environmental values are considered in the decision making process.

5.2.1 THE ENVIRONMENTAL IMPACTS OF SUBSURFACE MINING

- Change in quantity and quality of water, Water consumption effect;
- Potential impact on aquifer;
- Groundwater inflow expected into the mine,
- Drying of wetlands and, streams, lakes, ponds and springs;
- Surface water quality change;
- Dams, embankments and impoundments,
- Surface and ground water flow pattern change;
    - Change on current surface water use;
    - Change on horizontal extent of water table;
    - Change on aquifer recharge and storage characteristics;
- Location of waste, refuse ore and removed overburden;
- Location of the various mining operations;

- Blasting;
- Spreading dust;
- Noise effects;
- Major change on the economic activities and source of employment;
- Social effects (relocation of population, cultural change, impact of mining on human health, living conditions and well being, change in population size, availability of services, employment, business possibilities, conflicts among the population);
- Production of surface spoil heaps with sedimentation and acidification of water courses alteration of water quality of large area;
- Loss of agricultural productivity caused by change on the flora and fauna distribution and natural diversity due to subsidence. Surface subsidence takes place if mining is subsurface;
- Devastates fish and aquatic habitat,
- Erosion and sedimentation;
- Noise; vibration and blast effect,
- High temperature;
- Air pollution from dust, emissions,
- Limited light for the miners;
- Change on landscape;
- Surface soil texture disturbance and stripping of soil;
- Chemicalization of the environment by toxic pollutants such as
    - Acid mine drainage from active mines;
    - Acid drainage from abandoned mine;
    - Acid runoff;
    - Toxic heavy metals;
    - Chemical agents;

The mitigation measures are similar to the surface mining impacts, but in this type of mining securing and sealing of openings are important

- Surface cover and capping of openings
- Backfilling

- Shaft and adit plugs

6 HYDROCARBONS (PETROLEUM AND COAL) AND THE ENVIRONMENT

Every hour nearly 1000,000 tons of fossil fuel burns allover the world. When the fossil fuel burn they produce poisonous gases and pollute vast areas. 88% of the worlds commercial energy is produced from the non-renewable fossil fuel resources. Coal covers 28%, Oil 38% and natural gas 21% respectively. USA uses 12 ton coal equivalent per capital (TCE), Europe uses 5TCE per capital, developing countries use 0.5TCE per capital. But everyone is paying the cost of global environmental problem equally.

Exploration for petroleum in Ethiopia has been undergoing since 1920. Only small amount of condensate was discovered in 1971 in the Ogaden Basin. Exploration for coal is also progressing in southwest. Several hundred million tons of lignite rank coal and oil shale reserve have been proven so far in many pats of the country. According to the study of the World Bank (1983) petroleum energy consumption of Ethiopia is 6.5% of the total annual energy consumption.

6.1 GROUPS OF FOSSIL FUELS

Fossil fuels are classified as:

- Coal (peat, lignite, bituminous and anthracite);
- Oil;
- Natural gas;
- Oil shale (not used in Ethiopia at the moment).

6.2 ENVIRONMENTAL IMPACTS OF FOSSIL FUELS

- Impact during exploration (Ref. previous sections);
- Impact during development (Ref. previous sections);
- Impacts during use of fossil fuels;
- Land subsidence;

6.2.1 IMPACTS OF COAL MINE ON ENVIRONMENT

The effects of coal mines include:

- Landscape disruption on surface,
- Disturbance of land,
    - Removing vegetation,
    - Moving overburden,
    - Removal of coal
    - Erosion of soil,
    - Dust pollution,

- Acid mine drainage,
    - Contamination of drinking water,
    - Disruption of growth and reproduction of aquatic plants and animals, and
    - Corrosion of bridges
- Subsidence of surface if subsurface mine collapses,
- Accumulations of waste heaps,
- Health problems due to smoke, soot, SO_2, release of trace elements, and compounds of C, N, S;
- Dust due to loading and unloading;

6.2.2 IMPACTS OF COAL UTILIZATION

Environmental impact of coal utilization includes:

- Combustion related air pollution,
    - carbon dioxide from combustion,
    - Nitrous oxide,
    - Methane
- Respiratory related problems due to dust, SOx, NOx, suspended particles, O3, CO3, Hg, Se, F, B, Cr, V;
- Coal greenhouse gas,
- Waste disposal,
- Disposal of fly ash and residues;

Table 1 Summary of impacts of coal mine and use of coal on the environment

Source of impact	Primary exposure	Possible health impact
Subsurface mining	Dust, noise, diesel exhaust, (SO_2, CO, CO_2, H_2SO_4)	Pneumoconiosis, hearing loss, cancer, respiratory irritation.
Surface mining	Acid mine drainage, heavy metals (Pb, Cd, As), increase in pH	Cancer, Cardiovascular disease, etc.
Cleaning and preparation of coal	Dust, trace elements (Cd, Cr, Cu, Fe, Hg, Ni, Pb, Zn, As, Mn, Se,) SO_2, Organics	Cancer (respiratory, nasal, dermatitis, etc)
Transportation of	Dust, water contamination	Respiratory irritation

coal		
Combustion	Air emission, fly ash, residue	The above mentioned disease and loss of resistance to infection.

6.2.3 Mitigation of coal impacts

- Reduce emission by using best technology currently available,
- Use electric power for zero emission,
- Develop new emission control technology,
- Reduce dust by early vegetation,

6.2.4 IMPACTS OF OIL AND GAS ON ENVIRONMENT

Oil and gas are produced from very expensive deep wells. After produced from the wells the oil passes through many stages of distillation and refining process before it is used. In addition to the use of petroleum as source of fuel they are used as raw materials for petro-chemical industries. Oil spills and leakage on land can contaminate soil and subsurface water while evaporation of oil products and incomplete burning of oil fuels result in air pollution. In cities and towns oils and lubricants pollution of rivers and subsurface water takes place from fuel stations and garages. The soluble hydrocarbons that enter water system are benzene, toluene, ethyl-benzene, etc.

Impacts of oil are:

- Organic contamination of drinking water;
  - Cause cancer in human and animals,
  - Liver damage,
  - Impairment of cardiovascular function,
  - Depression of nervous system,
  - Brain disorder, etc.
- Release of CO_2 and H_2O from oil combustion,
  - CO_2 can cause global warming

6.2.5 MITIGATION OF THE OIL FUEL IMPACTS:

- Use of alternative energy source;
  - Geothermal,

- Solar,
    - Wind,
    - Hydrothermal, etc.
- Maximize use of fresh water based drilling mud,
- Recycle drilling mud,
- Store crude oil in thanks,
- Minimize and control leakage from thanks and pipelines, fuel stations to halt spill and leakage of oil;
- Develop system of handling used (old) engine oils and lubricants from garages;
- Improve in the fuel combustion efficiency of vehicles
    - Improving both design and mode of fuel use, such as compression ratio, turbocharger, decreasing the mass of the vehicles, rolling resistance of vehicles, regular servicing, etc
    - Fuel supplies should be stored above high water level
- If oil is spilled on land it should not be removed or buried. Attempts to do so can create more problem; the area affected can be
    - Fenced to protect wild life;
    - Introduce petroleum consuming local soil bacteria
- Stream crossing should be designed so that flow is not affected, causing deposition of sediments;
- Oil, drilling fluids, garbage, and other contaminants should not be dumped in lakes and streams;
- Cutting of line and stripping of vegetation should be minimized,
- If there is a possibility of contaminating drinking water wells, it may be advisable to grout all exploration holes.
- Test pits, trenches, and other excavations should be filled in after use.
- After/during production of petroleum, reservoirs should be injected with water and gas (air, such as nitrogen) to overcome surface subsidence

7 SMELTING (RECOVERING OF METALS), REFINING, AND MARKETING

Activities: Processing of mineral concentrates by heat or electro-chemical.

Environmental issues:

- Sulfur dioxide emission contribute to acid rain,
- Toxic chemicals,

- High energy requirements,

7.1 MITIGATION OF ACID DRAINAGE FROM MINE AND SMELTING SITES

In the case of precious metal heap leach operation cyanide neutralization of acid mine drainage takes place by:

- Natural degradation and detoxification;
- Covers and seals for exclusion of oxygen,

- Pilling of tailing under water for exclusion of oxygen,

- Cover and seal of tailings to reduce water infiltration,

- High UV level and strong winds for nine months would make natural degradation of cyanide;

- Rinsing with barren solutions (clean water)to clean the entire heap reduces the concentration of cyanide;

- Biological treatment for destruction of cyanide

    - Using of bacteria proven to oxidize cyanide

- Chemical treatment

    - Acid leachate collected in ponds neutralized with lime;

    - Sulfur dioxide and air oxidation method (added in conjunction with lime and copper catalyst);

    - Alkaline chlorination (either chlorine gas or calcium hypochlorite are used in the oxidation process);

    - Hydrogen peroxide oxidation (clean, but expensive)

    - Ferrous sulfate (chemical distraction of cyanide);

- Clean up of mine sites;

- Accurate prediction of site water balance

    - Discharge

    - Evaporation

    - And process requirement

- Abandoned mine land reclamation;

- The cover should be graded and compacted to minimize infiltration,

- Accurate prediction of geochemical behavior of waste rock, tailing, ore heaps, open pit, or subsurface workings when exposed to an oxidizing environment,
- Adequate physical and geochemical stablization of mine waste materials
- Adequate environmental and operational monitoring to identify charges in initial design assumptions,
- Control on disposal of mining and beneficiation waste;
- All process fluids should be detoxified and evaporated from the site,
- Control airborne toxic substances.

8 MINE CLOSURE AND DECOMMISSIONING

All mines will eventually close when the mines stops operating due to economic conditions. When a mine permanently stops appropriate mine closure should take place. The issues are waste rock landforms, process plant site, road/hardstands, infrastructure areas, open pits, etc..

8.1 IMPACTS OF IMPROPERLY CLOSED MINES

- Void collapse:
    - Subsurface subsidence
    - Slumping of tailing and waste rock pile
    - Wall failure,
    - Erosion and structural instability

Acid rock drainage

- External and internal instability,
- Acide soil,
- Gas emissions,
- Adverse groundwater and surface water quality

Public safety

- Human injury or death

8.1.1 MITIGATION

Backfill upper level of voids with waste rocks,

- Profiling,
- Ripping, and surface cover to prevent wind erosion,

- Drainage control,
- Capping tailings and waste rock with 1 m thick material
- Integrate subsidence, land form and river diversion
- Treat and replace acid water, introduce sulfides reducing bacteria, segregate known aquifers
- Environmental protection,
- Subsurface mine openings are sealed,
- Surface facilities are removed,
- Demolish plants, equipments
- Surface mines and the subsurface areas of subsurface mines are reclaimed.
- Secure pits, dumps,, impoundments, etc.
- Protect and clean up of ground water,
- Protect from acid rock drainage,
- Rehabilitate and re-vegetate
- Disposal of assets,
- Social mitigation, mine closure means a sharp drop in the standard of living for the local community and the region, tax revenue falls as demand for services increase
- Mitigating impacts on employees, the community and others whose jobs depend on mining, and a local government,
    - Retraining for other job,
    - Ensure food security and service delivery,
    - Protecting the most vulnerable,
- Subsurface mine openings are sealed,
- Surface facilities are removed,
- Surface mines and the subsurface areas of subsurface mines are reclaimed.

Only after these activities are completed can the mining company abandon the site.. Even after the mine is abandoned post mining liabilities rest with the mining company

The objectives of successful mine closure are to provide long-term protection to surface and groundwater resources, establish a stable physical setting, return the site to pre-mining or other land use, and develop a low-maintenance situation for the mining company. A period of post-closure monitoring is typically required.

8.1.2 Mitigation of mine site impacts

Mine closure sites environmental problems can be mitigated by:

- Restricting the mobility of constituents in heaps and impoundments,
- Sealing and rehabilitation of open pits and quarries,
- Eliminate any danger to the health and safety of the public,
- Backfill material selected must be free of acid / toxic forming and combustible materials
- Reduction of constituents in solution,
- Rinsing/treatment of tailings,
- Water balance,
  - Determine if a hydraulic head will be placed on the mine seal after closure,
  - Control the movement of subsurface water or hydrologic communication,
- Mine facility removal
  - Demolition of existing structures,
  - Debris removal,
  - Debris disposal,
- Waste disposal areas,
- Utilities and roadways,
- Drainage facilities,
- Removal of hazardous materials,
- Percolation of solution through heaps, and
- Acid generation from tailings and waste rocks, tailing impoundment,
- Control tailing erosion, slope failure, weathering, drainage disruption,
  - Establish erosion resistant cover of vegetation soil, riprap or water cover,
  - Appropriate site selection and dam design,
  - Implement permanent control measures,

Most mines are required to post a reclamation performance bond that is to be used by a regulatory agency to reclaim an area in the event of forfeiture. The setting of rehabilitation bonds serves the purpose of reducing the risk of failure of the lease holder to the government to meet the environment management commitments. Several methods are introduced.

- Irrevocable Letter of Credit – an agreement between the company and the bank where by bank will provide cash funds to the authorities if the company defaults;

- Performance Bond – a surety bond issued by an insurance company in which the insurer is responsible for all claims up to an agreed limit;

- Trust Fund – a fund that operates in a similar fashion to a pension fund with regular contributions being invested by a fund manager,

- Insurance policy- a special form of performance bond,

- Parent _Company Guarantee-the parent company guarantees to indemnify the Government in the events of a company default,

- Pledging of Assets-the company assets are pledged to the Government.

The above methods of rehabilitation bonds arrangement are taken from the experiences of Queensland state of Australia.

8.2 ENVIRONMENTAL ISSUES DURING DECOMMISSIONING

The following factors are important when considering decommissioning a mine.

- Public safety hazardous and risk,
- Ecological compatibility,
- Potential as on going source of pollution,
- Community expectation,
- Future land use and resource demands,
- Aesthetics
- Seepage of toxic solutions into ground and surface water contamination from acid mine drainage,
- Wildlife and fisheries habitat loss,
- Re-vegetation failure,
- Wind borne dust,
- Slope and tailings impoundment failure,

8.3 ACTIVITIES (MITIGATION):

- Demolition or disposal of structures and buildings,
- Removal of foundations and debris,
- Ongoing seepage control,
- Long term stability of waste rock disposal area against water and wind erosion,
- A conformational geochemical evaluation determined no potential impact to ground water from infiltration of precipitation through the waste rock disposal area
- Re-contouring of pit walls, and waste dumps,

- ➢ Covering of reactive tailings dumps,
- ➢ Decommissioning of roads,
- ➢ Dismantling of buildings,
- ➢ Re-seeding/planting of disturbed areas,
- ➢ Monitoring and possible water quality treatment.
- ➢ Rehabilitation measures

- Sealing of subsurface workings and rehabilitation of dangerous excavations,
- Prevent inadvertent access, and permanently seal openings
- Surface stabilization and re-contouring,
- Underground stabilization,
- Control reactions
- Control migration of elements and water,
    - Permanently plug workings and drill-holes to control migration,
- Collect and treat acid mine drainage,

8.2 ENVIRONMENTAL MONITORING AFTER CLOSURE

Monitoring is carried out for physical stability, chemical stability, and for environmental impact. The purpose of post-closure monitoring is to evaluate the success of closure activities, to map out the actual environmental impact and the resulting changes in the environmental conditions in the impact area of a project. After reclaiming a mine site, there will probably be several years of maintenance activity required. This will include periodic inspection of the site to verify that the reclamation is effective. Areas need monitoring are shaft, adits, plugs, slopes, covers, dams, ditches, etc. The impacts are:

- Access disturbance,
- Surface slumps,
- Erosion,
- Acid generation and leaching of metals,
- Waste rock land forms
    - Erosion
    - Dust

Tailings storage problems

- Seepage
- Erosion

Process plant sites

- Infrastructural areas
- Underground workings

    - Subsidence,

    - Shaft vent capping

Open pit

- Pit wall stability
- pit water quality

- Adjacent band down stream areas

    - Dust

    - Surface water quality

Potential Monitoring Activities (methods) include:

Visual inspection

- Inspect ditches, berms, fences, signals,
- Look for cracks, scraps, change in drainage patterns,

- Displacement and settlement,

- Seepage,

- Flow rate of leakage,

- Alluvial fans,

- Piezometers,

- Debris and blockages,

- Sampling of down stream surface and groundwater drainage

- Verification that mine seals are effective,

- Cleaning out of sediments and erosion control structures, primary ponds and ditches,

- Verification that the water discharges are within the permited effluent limited,

- Regarding and reseeding of areas, as required,

    - The quality of surface and groundwater,

    - The level of groundwater, the quality of process water led into the waterways; and

    - The spreading of dust.

8.4 MONITORING MEASURES

- Visual inspection,
- Analysis of sediment loading in runoff,

- Monitoring bore,

- Water sample analysis, etc

9 SOCIO-ECONOMIC CONSEQUENCES OF MINES CLOSURE ON LOCAL COMMUNITY

Socioeconomic impacts need to clarify the type, duration, spatial, extent and distribution of the impact. This incorporates: direct verses indirect impacts, period of time (exploration to closure and beyond) the boundaries of the impact zone, and the affected group.

- Exploration is first and the least intrusive. It involves a small work force for limited period of time,
- The period of mine development and of plants for associated surface activities is the most disruptive event. It lasts for a few years, but can involve the largest number of people. Work force is transient in character,

- The period of mine and plant operation is the longest, often two decades or more. It usually provides the greatest economic rewards to the community,

- The final stage is abandonment. This is negative event on both economic and social counts,

- A large temporary increase in local employment increases local demand in housing and all types of public services,

- The groups of workers will change throughout the period, because the type of workers needed shifts as development progresses,

- Retail and service establishments increase,

- Increase of local wage, cost of housing and property taxes,

- Overload roads, schools, public and private services,

- Mine closing can impact community who were providing goods and services to the mine,

- Abandonment of mine may leave population stranded without sufficient economic activities and can create ghost towns and villages.

- The demography and settlement patterns including potential changes due to relocation and migration,

- The land use systems and natural resource utilization and the possible impact,

- The cultural and social impacts, including business development, mine-related payments, social disruptive influences and law and order,

- The health and nutrition status of the population and adequacy of health facilities and the potential for mine related change,

- The education facilities and services, employment and income level of the people in the immediate area of the project,

- The existing transport, power, water, sewage, waste disposal, police, etc. services and the impact of the project on these services,

- Compensation for project related environmental impacts and social disruptive,

- Family split

9.1 MITIGATION

- Unemployment compensation,
- Retraining for other jobs,

- Relocation and enticements for new businesses to locate locally.

9.2 OCCUPATIONAL HEALTH IMPACTS

If environmental stress exceeds human tolerance level for prolonged periods of time,

- Feeling of discomfort will arise,
- Alertness will decrease,

- Accident will occur,

- Performance and productivity will drop.

The main sources of impacts are:

- Poor handling of chemicals,
- Fugitive emission within the plant from transport, blasting, and combustion,

- Exposure to asbestos, cyanide, mercury or other toxic materials,

- Exposure to heat, noise, vibration,

    - Mine fire, Heat strokes

- Physical risk at the plant or at the site,

    - Threats to a miner's safety may arise from:

    - Fall of roof, face, rib or side of a mine pit,

    - Haulage or other machinery accident,

    - Electrical equipments;

    - Explosives, or ignition or explosion of gas and dust;

    - Sudden inundation of water and gas;

    - Injuries and lose of life through suffocation;

- Dust inhalation,

- Disease such as silicosis, asbestosis and pneumoconiosis,

9.3 MITIGATION OF OCCUPATIONAL HEALTH IMPACT

Dust control,

- Use water for dust suppression
- Apply exhaust ventilation
- Dust filtration techniques

- Control of noise and vibration
  - Use slower running equipments
  - Improve maintenance,
  - Replacing compressed air equipments by electrical devices,
  - Use air silencer, resilient mountings,
- Establishment of policies and priorities to initiate safety programs
- Provision of education and training;
- Choice of personnel for specific job;
- Commit resources;
- Pro-active safety system ,
- Provide leadership in safety.

9.4 GENDER DIMENSION OF MINING

Women are largely absent from the technical aspects of large scale mining operations for legal reasons such as the International Labor Organization(ILO) convention 45 (Ref. Third World Network Africa, 2001), and women's limited capacity to manage gangs of men, risk involved in the sector, hostility and chauvinism from their male counterparts in the field, limitation of women to invest in mining, and traditional reasons. In large scale mining women are limited to legal, public relations and catering and financial work. The participation of women in artisanal mining is higher in comparison to man. In Ethiopian there is no large scale mining and segregation of women from men in mining operation at the moment. The artisanal mining for gold in most of the regions in Ethiopia is managed by women and children.

However, it is important to recognize the potential social impact of mining operations on women and children. In countries that have large scale mining, the people's ancestral land and natural resources have been plundered, and the environment and indigenous culture eroded drastically as the long-term effects of large-scale mining take their toll.

9.4.1 IMPACTS OF MINING ON WOMEN:

The effects of large-scale mining on women include the following:

- Deprivation of ancestral land rights,

- Loss of farm land;
- Loss of traditional livelihood and impairment of the productive role of women,
- The workload of women increases at home as men work in a cash economy created by mining operations and women have increased responsibility for the household and food provision through traditional means;
- Women suffer from an increased risk of HIV/AIDS and other STD infections, family violence, rape and prostitution often fuelled by alcohol abuse and/or a transient male workforce;
- Exposed to sexual exploitation,
- Cultural impacts on women and children,
- Ecological destruction,
- Mining industry is conducive to HIV/AIDS transmission, increases sexually transmitted disease, spread of communicable from migrant and transient miners; sexual harassment and increased incidences of violence against woman in local communities by transient male mine workers,
- Pressure on housing in time of rush for mining and other social service;
- Water pollution from the mine;
- Introduction of alcoholism (development of bars, sex shops) and drugs
- Migration of husband to work as miner; it can end up on divorce
- Inflation on the local economy;
- Unfilled pits pose threat to women searching for fuel wood;
- Limitation of access to herbs, traditional spices, plant materials for soap or cosmetics, edible mushrooms that women use for their family.

9.4.1 MITIGATION

Gender awareness requires gender sensitive attitudes, a commitment to placing both women's and men's needs and priorities at the centre of development work, analysing the impact of projects on women and men, and designing projects that involve both women and men. It requires knowledge about the impact that development activities will have on both women and men, which must involve an understanding of women's and men's social and economic relations and experiences. control of resources, meeting practical gender needs does not necessarily challenge existing gender norms. Practical gender needs, gender sensitivity gender analysis, empowerment, gender mainstreaming, strategic gender interests–involve bringing about equality between men and women. They transform gender relations by challenging women's disadvantaged position or lower status. Meeting strategic gender interests involves working with men as well as women to change assumptions about women's role and place in society. If these were met, the existing relationship of unequal power between women and men would be transformed.

10 NVIRONMENTAL PLANNING

To minimize the impacts due to any mine activities on environment, preparation of environmental planning is necessary. The environmental plan should include:

- Erosion and sediment control plan,
  - Capacity of the structures,
  - Operations and maintenance of these structures,
  - Method of sediment retrieval,
  - Nature and location of sediment disposal facilities,
  - Wind erosion,
  - Water erosion,
- Schedule of operations,
- Mine development rock, ore and concentrate management,
  - Type of ore and rock that will be removed
  - The tonnage that will be removed,

        - The tonnage of tailing that will be placed on surface,
        - The backfill methods,
        - The slope, the face, and the pit wall stability,
        - Access and haulage routes
        - Safety and security plans for workers and public,
- Tailing disposal and impoundment plane,
    - The area to be covered by waste piles
    - Site preparation plane,
    - Total height of each pile plane,
    - The original topography,
    - Tailing disposal methods,
    - Chemical characteristics of the tailings,
    - Acid generation potential of the tailings
    - The generation controls necessary for acid drainage,
    - Water management and treatment plane
- Ongoing monitoring plane,
    - All impacts to be monitored,
    - Monitoring frequency,
    - Location of monitoring points,
- Ongoing rehabilitation/ reclamation plan
    - Original topography plan
    - Superficial and bed rock geology
    - Plan of areas to be covered
    - Total height of each pile or dam
    - Material types, their physical and chemical properties,
    - Seepage control plan
- Sewage sludge disposal plan
- Chemicals and fuel storage and handling,
- Buildings and infrastructure plan,
    - Nature and location of all structures,
    - Construction materials used,
- Solid waste disposal pla,ne,
- Work place air quality monitoring plan
- Hazardous material handling plane,
- Safety plane,
- Resettlement plan for displaced people,
- Mine closure planning,
    - Cost estimation and time line
    - Final land forms and configuration
    - Identifies and addresses risks and uncertainty
    - Defines implementation and post closure monitoring arrangements
- Post-closure monitoring plan,
    - Surveillance, monitoring and auditing
- Rehabilitation plan,
    - Physical stability plan,
        - Materials and structures remaining on site after operations have ceased
    - Chemical stability plan,
        - Acid mine drainage
        - Leaching of materials,
        - Measures for the control of chemical reactions and the treatment and control of drainage,
        -
    - Human safety plan,
    - Future land use

11 SUMMARY AND CONCLUSION

Mining designers must consider the effects of mine on its surroundings. Engineering alternatives have to be judged according to their environmental influence. After a plan is adopted , the effects on the environment should be monitored.

In the early stages of a mining venture maintaining environmental quality is usually inexpensive. However, stacking, line cutting, geophysical surveying and drilling are done by contractors who may not be concerned with protecting the developers image.

When decision is made to bring an ore body into production, the local ecology along with social and economic conditions should be studied. This provides base line data against which to measure the effect of mining. Monitoring of the effect of mining include: physical aspects such as depth, temperature, sediment texture, water characteristics such as colour, terbidity, dissolved solids and organic content, toxicants such as heavy metals and detergents, biota such as phytoplankton, concentration, plants, fish and bacteria.

Plant operation will affect the local economy and population distribution and will constitute a new land use. Local road and the community water may be significantly affected.

The problem of acid contamination from mines and waste arises from the presence of pyrite, pyrrhotite and chalcocite. Production of acide can be prevented by excluding any one of oxygen, water or sulphides

The cost of antipollution program may be minimized by determining water quality before operation start. This will prevent having to fulfill subsequent quality requirements that exceed the natural conditions.

Recycling of water may be possible, thereby reducing fresh water requirements. This could reduce the volume of water to be treated.

Reclamation requires establishing objectives for ultimate use of the site. Blasts should be designed to avoid damaging vibration.

Government, mining companies and communities should as a minimum recognize environmental management as a high priority, notably during the licensing process and through the development and implementation of environmental management system. These should include commitment to:

- Early and comprehensive environmental impact assessment,
- Pollution control and other preventive and mitigation measures,
- Monitoring and auditing activities, and emergency response measures.
- Establish environmental accountability in industry and Government at the highest management and policy-making level,
- Encourage employee at all level to recognize their responsibility for environmental management and ensure that adequate resources, staff, and requisite training is available to implement environmental plans,
- Ensure the participation and dialogue with the affected community and other directly interested parties on environmental aspects of all phases of mining activities,
- Adopt environmentally sound technology in all phases of mining activities and increase the emphasis on the transfer of appropriate technologies which mitigate environmental impacts including those from small scale mining operations,
- Adopt risk analysis and risk management in the development of regulation and in the design, preparation, and decommissioning of mining activities, including the handling and disposal of hazardous mining and other wastes,

- Avoid the use of such environmental regulations that act as unnecessary barrier to trade and investment,

- Recognize the linkage between ecology, socio-cultural conditions and human health and safety, both within the workplace and the natural environment,

- Continuous improvement in environment performance,

APPENDICES

Appendix 1 AIR, WATER AND SOIL QUALITY STANDARDS

A, Air Quality Standards: Discharges to Air (Source: Ministry of Environment, British Columbia, Canada. 1989).

Parameter	Maximum discharge (parts per billion)
Sulpher Dioxide	
Annual arithmetic Mean	75.00
24 hour concentration	260.00
3 hour concentration	665.00
1 hour concentration	900.00
Antimony (Sb)	0.50
Arsenic (As)	1.00
Beryllium (Be)	0.1
Cadmium(Cd)	0.30
Chromium (Cr)	0.10
Copper(Cu)	2.50
Fluorine(F)	2.00
Lead (Pb)	2.50
Mercury (Hg)	1.00
Molybdenum (Mo)	2.50
Nickel (Ni)	0.10
Selenium (Se)	0.50
Uranium (U)	6.00
Vanadium (V)	1.00
Zinc (Zn)	2.50

B Soil Quality criteria (Tentative Netherlands Soil Quality Criteria)

	Soil quality criteria		
	Concentration (mg/kg dry weight)		
Parameter	A*	B*	C*
Arsenic (As)	20	30	50
Beryllium (Be)	200	400	2000
Cadmium(Cd)	1	5	20
Chromium (Cr)	100	250	800
cobalt	20	50	300
Copper(Cu)	50	100	500
Lead (Pb)	50	150	600
Mercury (Hg)	0.5	2	10
Molybdenum	10	40	200
(Mo)	50	100	500
Nickel (Ni)	20	50	300
Tin	200	500	3000
Zinc			

A* Reference value for good soil.
B* Limiting value for soil quality having potential for harmful effects on human health or the environment and requiring further investigation.

C* Limiting value for heavily polluted soil requiring remedial investigations and clean up.
Source guideline for soil clean up – Netherlands Ministry of Housing, Planning and Environment, Soil, Water and Chemical substance Department, The Hague, Netherlands, 1983.

C Tentative Netherlands Ground and Surface Water Quality Criteria

Parameter	Ground and surface water quality criteria		
	Concentration (mg/L)		
	A*	B*	C*
Arsenic (As)	10	30	100
Beryllium (Be)	50	100	500
Cadmium(Cd)	1	2.5	10
Chromium (Cr)	20	50	200
cobalt	20	50	200
Copper(Cu)	20	50	200
Lead (Pb)	20	50	200
Mercury (Hg)	0.2	0.5	2
Molybdenum	5	20	100
(Mo)	20	50	200
Nickel (Ni)	10	30	150
Tin	50	200	800
Zinc			

D UK Environment Agency Environmental Quality Standards for Water

Parameters	Environmental quality standards(parts per billion for the elements)
PH	6-9
Arsenic (As)	50
Cadmium	1
Copper(Cu)	28
Iron	1000
Nickel (Ni)	200
Zinc	500

APPENDIX 2 SUGGESTED TABLE OF CONTENT FOR MINING STAGE EIA STUDY REPORT

1 Background information and project objectives

1.1 Introduction
1.2 Status of the project site

1.3 Ownership structure

1.4 Project objectives

1.5 Environmental impact assessment objectives

1.6 Legislative requirements

1.7 Analysis of need for the project

1.7.1 Corporate need

1.7.2 Export prospect

1.7.3 National benefit

2 Geology

2.1 Previous exploration and mining

2.2 Geological setting

2.3 Overburden/ inter-burden

2.4 Structures

2.5 Ore resource

2.6 Ore reserves

3 Project description

3.1 project concept

3.1.1 outline

3.1.2 site constraint

3.1.3 work practice implication

3.2 Production rates

3.3 Projected product sales

3.4 Overburden and inter-burden removal

3.5 The mining plan

3.6 geo-technical considerations

3.7 Transport

3.7.1 Ore, waste, concentrate

3.7.2 Chemical

3.8 Infrastructure

3.8.1 Construction facilities

3.8.2 Site access

3.8.3 Site development and earthwork

3.8.4 Site facilities

3.8.5 Power

3.8.6 Fuel storage

3.8.7 Maintenance and repair workshops

3.8.7.1 Laboratories

3.8.7.2 Temporary accommodation

3.9 Service activities

3.9.1 sewage and garbage disposal

3.9.2 chemical storage and handling

3.9.3 weed and pest control

3.9.4 medical service

3.10 Workforce

3.11 Workforce transport

3.11.1 construction phase

3.11.2 Operational phase

3.12 Energy

3.13 Alternatives

3.13.1 No development option

4 Ore handling, preparation, and product transportation

4.1 Ore handling

4.2 Mineral preparation

- Plant capacity
- Ore handling and storage
- Processing plant capacity
- Product handling capacity
- Rejects handling capacity
- Train/truck loading capacity

4.2.2 Design basis and overall concept

4.2.3 Plant description

4.3 Product transportation

4.3.1 Reclaim and train/truck loading

5.7.2 Geochemical considerations

6 Rehabilitation

6.1 legal requirements

6.2 post-mining land use

6.2.1 alternatives

6.2.2 prefered post mining land use

6.3 Land form design

6.4 Revegetation procedure

7 Existing environmental and environmental impact assessment

7.1 Physiography

7.2 Soil

7.2.1 soil survey
7.2.2 soil p[rofile description

7.2.3 suitability of soils for stripping, stockpiling and topdressing

7.2.4 erosion status

7.2.5 environmental management of soils

7.2.6 Hydrology and water quality

7.2.7 Hydrologic history, flood level,

7.2.8 Surface water usage, water quality, monitoring program

7.2.9 Groundwater: aquifer characteristics, registerd groundwater bores

7.2.10 Long and short-term impact assessments-hydrology and water quality

7.3 Climate and air quality

7.4 Acoustics

7.4.1 Major noise source from the project

7.4.2 Noise impact assessment

7.4.3 Nois mitigation

7.4.4 Blasting

7.5 Vegetation

7.5.1 Inventory of vegetation species

7.5.2 Open woodland and wholly cleared land

7.5.3 Vegetation along water ways

- Population
- Density
- Valued population of species

7.6 Fauna

7.6.1 inventory of species

- population
- migratory characteristics
- habitat
- endangered, rare or threatened species

7.7 Historical background

- Local history
- Anthropology
- Archaeology

7.8 Land use, capability, tenure and zoning

7.8.1 Land use

- Traditional land use pattern
- Cropping
- Horticultural
- Dairy farming
- Drayland grazing
- Urban land use
- Agricultural trends

7.8.2 Rural land capability

7.8.3 Land tenure and zoning

7.9 Aesthetics

7.9.1 Existing landscape characteristics

7.9.2 Impact assessment-aesthetics

7.10 Transport

7.10.1 Road network

7.10.2 Impact assessment

7.11 Employment characteristics

7.11.1 Effect of proposed development on employment

7.11.2 Demographic characteristics

7.11.3 Impact of the proposal on population

7.11.4 Impact assessment-socio-economics

7.12 Housing and community services

7.12.1 community service and facilities

sewage, water supply and garbage disposal

7.13.4 health services
7.13.5 community infrastructure

7.13.6 vector control

7.13.7 impact assessment-housing and community services

8 Environmental monitoring program

8.1 Air quality

8.2 Water quality

8.3 Geochemical

8.4 Noise and vibration

8.5 Rehabilitation

9 Project team and references

10 Appendices and figure

APPENDIX 3 CHECK LIST OF MINERAL AND PETROLEUM OPERATION AND MINERAL PROCESSING

The EIA study should be checked if it fulfils one or more of the criteria set

out below.

1 **Legal compliance:**

A, Has the proposed project met the requirements of the mining, and petroleum operation laws and environmental policy and laws of Ethiopia?

B, Provide lists of all permits existing, and current status of each permit

C, Were any citizen protest or comments filed

D, What is the status of the bond (not for exploration)

E, has the mine had a permit to use explosives

2 **Phase of operation**

A, Is the project in exploration, development, mining or smelting stage of operation?

B Was base line data survey conducted?

3 **Will the project cause**

a, substantial pollution problem on soil, surface water, groundwater?

b, create substantial waste disposal problem?

C, accident for the local population and the workers

D, affect areas which support animal and plant life or areas with particularly vulnerable ecosystems?

E, lead to major change in the landscape?

F, Affect areas with historical/ cultural remains/aesthetic or scientific value

G, Change the way of life of the local population

H, Obstruct, or lead to substantial changes in the local population the exploitation or use of natural resources other than those directly affected by the project?

I, Groundwater change?

J, Down stream water quality and water supply volume change?

4 **Will the infrastructure development cause:**

a, Soil erosion/silt runoff?

B, dust/noise/vibration/quarry hazard (blasting and hauling)?

5 **Will the project require significant volumes of:**

A, Local material?

B, Water or energy?

6 **Socio-economic conditions**

A Resettlement or compensation of local people?

B Will the size of affected population be significant?

C Will the project cause health problem?

D Will the Project cause existing land use change?

7 Will the project cause subsidence?

A, Does the mine include pillar removed mining?

C, Has there ever been any complaint by surface owner about surface subsidence?

D, Does the mine have any injection wells or pump any fluids or other material of any type subsurface?

8 Waste disposal

A Does the pile have any public roads, homes or occupied dwellings, etc. down stream that could be affected by failure

9 Impoundments and dams

10 Backfilling and slides

11 Subsurface injections

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