Mining Environmental Management

CODES OF PRACTICE

Mine Reclamation and Closure Plans

Guyana Geology and Mines Commission
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1.0 Introduction

This Code of Practice for **Mine Reclamation and Closure** in small and medium-scale gold and diamond mines is intended to provide environmental management guidance and promote the related best management practices. It is not a design manual[1].

1.1 Regulatory Authority/Mandate

The Mining (Amendment) Regulations 2005[2] were promulgated in 2004. Regulation 248 of the Mining (Amendment) Regulations 2005 stipulated that the Guyana Geology and Mines Commission (GGMC) prepare Codes of Practice for Mining Environmental Management prior to their incorporation into the Regulations.

The Codes of Practice were intended to provide critical environmental guidance to the Mining Industry, particularly small and medium-scale gold mines. The importance of the codes was even more enhanced by the development of the Low Carbon Development Strategy.

The following ten (10) provisions of the Codes of Practice for Environmental Management were indentified:

- Use of Mercury
- Tailings Management
- Contingency and Emergency Response Plans
- Mine Effluents
- Mine Reclamation and Closure Plans
- Mine Waste Management and Disposal
- Environmental Effects Monitoring Program
- Quarrying
- Sand and Loam Mining
- Use of Small Dams for the Control of Water and Tailings

1.2 Justification for the Mine Reclamation and Closure Plans Code of Practice

Site disturbance before, during and after mining is the most visible impact to the public. The mined-out, abandoned, and un-reclaimed mine properties reflect environmental degradation, socio-economic limitation, poor management practices and non-compliance with existing mining regulations. In some cases land instability and catastrophic-failures of structures such as tailings dams represent a potential risk during and perhaps long after operations.

[1] This document is **NOT** a design manual. Users of this document shall assume full responsibility for the design of facilities and for any action taken as a result of the information contained in this document.

[2] The Mining Regulations, made under the Mining Act (1989), was amended by the Mining (Amendment) Regulations 2005: Collectively they address all the important aspects of mining environmental management.

In Guyana there is a growing public demand for adherence to the Mining Regulations, mitigation of the impacts of unreclaimed properties and practice of sustainable mining in the gold and diamond industry.

The best management practices in the mining industry do not see the control of such impacts as an externality to be left to future generations or to be remediated at public expense. Reclamation has become an integral part of a mining operation. The *cradle-to-grave approach* is now prevailing in the mining industry.

Mine reclamation and closure is the process of decommissioning a mining operation with the broad objective of leaving the area in a safe and stable condition consistent with the surrounding physical and social environment and projected post-mining land use.

This Code reflects sound management practices followed in other countries. Its principles and approaches are also taken from various sources. It is the result of a comprehensive literature review. Valuable inputs from the participants at the Code development workshops were also incorporated into the Code. This Code of Practice provides important environmental management guidance to mine owners, operators and regulators on the Reclamation and Closure Plan Regulations.

1.3 Administration of Codes and Responsibilities of Owners and Workers

A useful strategy for sustainable environmental management in the small and medium-scale gold and diamond mining is co-regulation by the various stakeholders including the GGMC, and the Miners, and Mining Industry.

GGMC's mandate or role as defined by the Mining Act 1989 and the Mining (Amendment) Regulations 2005 is to develop, administer and enforce the mining regulations. Regulations 227 (1) (4) and 248 provide the basis for the Mine Reclamation and Closure Plans Code of Practice. Specific GGMC responsibilities include:

- Development and upgrading of the codes of practice
- Consultations with the stakeholders in the mining industry including mining organizations and miners on the development, and utility of the Codes 0f Practice.
- Public education, orientation and training
- Enforcement of, and monitoring compliance with, the Mining (Amendment) Regulations 2005

The prime responsibility for the implementation of, and compliance with, the Mining (Amendment) Regulations 2005, and the application of sound environmental management practices rests with the Mine Owners and Operators. Specifically, with respect to the Mine Reclamation and Closure Plans, the Mine Owners and Operators must:

- Manage their operations in compliance with the Mining (Amendment) Regulations 2005, the related Codes of Practices and Guidelines
- Prepare and implement a Mine Reclamation and Closure Plan consistent with this code of practice and Guidelines prepared by GGMC.

- Provide their employees with required training and orientation on the Mine Reclamation and Closure Plans, and the related the regulations, best management OHS practices, codes and guidelines

2.0 Glossary of Terms

Acid Rock Drainage (ARD)	Drainage of acid water containing dissolved metals as a result of natural oxidation of sulphides found in waste rock, ore and tailings exposed to wind, air, and water.
Best practice	The best way of doing things. The objective of best practices is to prevent or (when that is not possible) minimize risks to human health, as well as adverse environmental, social and economic impacts.
Buffer areas (Zones)	Means land on either bank of rivers or watercourses from the low watermark of the bank to 20 meters (20 m) inland, and extending from the mouth of the river or navigable watercourse to its source; or any area within 30 meters (30 m) of a public road; or 100 meters (100 m) of approved residences, commercial/industrial developments; or 1 kilometer (1 km) of an approved nature reserve or park.
Co-Regulation	The mechanism whereby a *Community legislative act* entrusts the attainment of the objectives defined by *the legislative authority* to parties which are recognized in the field (such as economic operators, the social partners, non-governmental organizations, or related industry associations).
Code of practice	Means the Environmental Code of Practice for the operation of mines that is published by the Commission and which shall be read as part of the Mining (Amendment) Regulations 2005. (A collection of rules and ethical principles related to a specific field of activity. A code of practice describes procedures and sets out standards considered to be best practices in the said field of activity. The code may be voluntary or mandatory)
Comminution	The breaking, crushing, or grinding by mechanical means of stone, coal, or ore, for direct use or further processing.
Decant tower	A vertical intake structure (riser) connected to a horizontal conduit that runs under the impoundment. The riser skims clear water (decant) from the surface of an impoundment and conveys it (water) by gravity via the underground conduit to a receptacle or reservoir.

Effluent	Means any fluid including airborne particles of matter and other substances in suspension or solution in the fluid and includes mine de-watering discharges , site runoff , discharges from a tailings basin or settling pond, discharges from a processing plant or dredging operation which is released to the surface or ground water and other substances such as colloids , in solution or suspension.
Encapsulation	A disposal process whereby a mining waste is covered and enclosed in such a way that no leakage can occur under normal circumstances.
End of mine life process	A process undertaken when the mining operation is about to be decommissioned or safely closed down.
Externality	In project analysis, an effect of a project felt outside the project and not included in the valuation of the project. In general, economists consider an externality to exist when production or consumption of a good or service by one economic unit has a direct effect on the welfare of producers or consumers in another unit.
Guidelines	A non-binding document, usually designed to provide users with information, explanations, guidance and help with respect to a specific topic. Guidelines are a tool frequently used to enforce new regulations. Users can be either the Regulator itself or the industry.
Medium-scale mine	A mine for which a mining permit has been issued and from which a volume in excess of $200m^3$, but less than $1000m^3$ of material, inclusive of any overburden, is excavated or processed as an aggregate in any continuous period of twenty-four hours.
Mine	Includes any excavation, processing facility and/or related facilities for the recovery of metal, mineral or quarriable material and excludes any excavation, processing facility or related facilities that excavate or process less than $20m^3$ in any continuous period of twenty-four hours
Mine closure	A whole of mine life process which typically culminates in property relinquishment. Closure includes decommissioning and rehabilitation. This term is often used interchangeably with Mine decommissioning.
Mine decommissioning	The process that begins near, or at, the cessation of mineral production. This term is often used interchangeably with Mine Closure.
Orphan site	An abandoned mine for which a responsible party no longer exists or cannot be located.

Overburden	Loose soil, sand, gravel, etc., that lies above the bedrock or above a deposit of useful materials, ores, or coal. Also called burden, capping, cover, drift, mantle, and surface, it may or may not include topsoil.
Progressive reclamation	Reclamation that is carried out throughout the mine life in day-to-day operations
Reclamation (rehabilitation)	The return of the disturbed land to a stable, productive and self-sustaining condition, taking into account beneficial uses of the site and surrounding land.
Regulations	A type of "delegated legislation" enacted by a state, or local government agency given authority to do so by the appropriate legislature Regulations are generally very specific and are also referred to as rules or simply administrative law. Regulations are official rules and must be followed.
Relinquishment point	Point where the mining company has met agreed completion criteria to the satisfaction of the responsible authority. At this point, the site is no longer a danger to public health and safety is not a source of ongoing pollution or instability and allows a productive use of the land similar to its original use, or approved alternative beneficial use. A mining company has no further obligations regarding a specific property once its relinquishment has been accepted by the regulatory authorities.
Risk assessment	The process of addressing what could go wrong with a mine or facility and its associated plans and procedures and what are the consequences of failure. Risk assessment provides a basis for the development of risk management, including communication, contingency, mitigation and emergency response plans.
Small-scale mine	A mine for which a claim license has been issued and from which a volume in excess of $20m^3$, but less than $200m^3$, of material, inclusive of any overburden, is excavated or processed as an aggregate in any continuous twenty-four hour period.
Stripping	The removal of earth or non-ore rock materials as required to gain access to the desired ore or mineral materials; the process of removing overburden or waste material in a surface mining operation.

Stripping ratio	The unit amount of spoil or overburden that must be of overburden to raw tons of ore or mineral material.
Sustainable Development (SD)	Development that meets present-day needs without compromising the ability of future generations to meet their needs.
Tailings	The gangue and other waste material resulting from the washing, concentration, or treatment of ground ore. Also those portions of washed ore that are regarded as too poor to be treated further
Tailings dam	Impoundment to which tailings are transported, the solids settling while the liquid may be withdrawn.
Temporary closure	Phase following temporary cessation of operations when infrastructure remains intact and the site continues to be managed. Also called Care and Maintenance.
Topsoil	Dark-colored, organic, well-decomposed soil material consisting of the residues of plant and animal materials together with synthesized cell substances of soil organisms and various inorganic elements.
Turbidity	The state, condition or quality of opaqueness, cloudiness or reduced clarity of a fluid, due to the presence of suspended material
Whole-of-mine -life process	A process that is carried out throughout the life of a mining operation.

3.0 Mission and Objectives

3.1 Mission Statement

The following is the Code's mission statement:

To foster sustainable practices so as to prevent and minimize adverse long-term environmental impacts generated by small- and medium-scale mines in Guyana and to create a stable landform suitable for some agreed subsequent land use.

3.2 Objectives

1) Ensuring that mine sites are restored to a satisfactory condition by:

- Eliminating/removing unacceptable health hazards and ensuring public safety
- Limiting the production and circulation of substances that could damage the receiving environment
- In the long-term, trying to eliminate the need for maintenance and monitoring
- Restoring the site to a condition in which it is visually acceptable to the community
- Reclaiming the areas where infrastructures are located for future use.

2) Improve the level of awareness and education of all parties on the importance of incorporating reclamation planning stage of a mine operation.

3) Ensure that reclamation and closure practices are adaptive and dynamic over time.

4) Ensure that reclamation and closure practices are credible and verifiable.

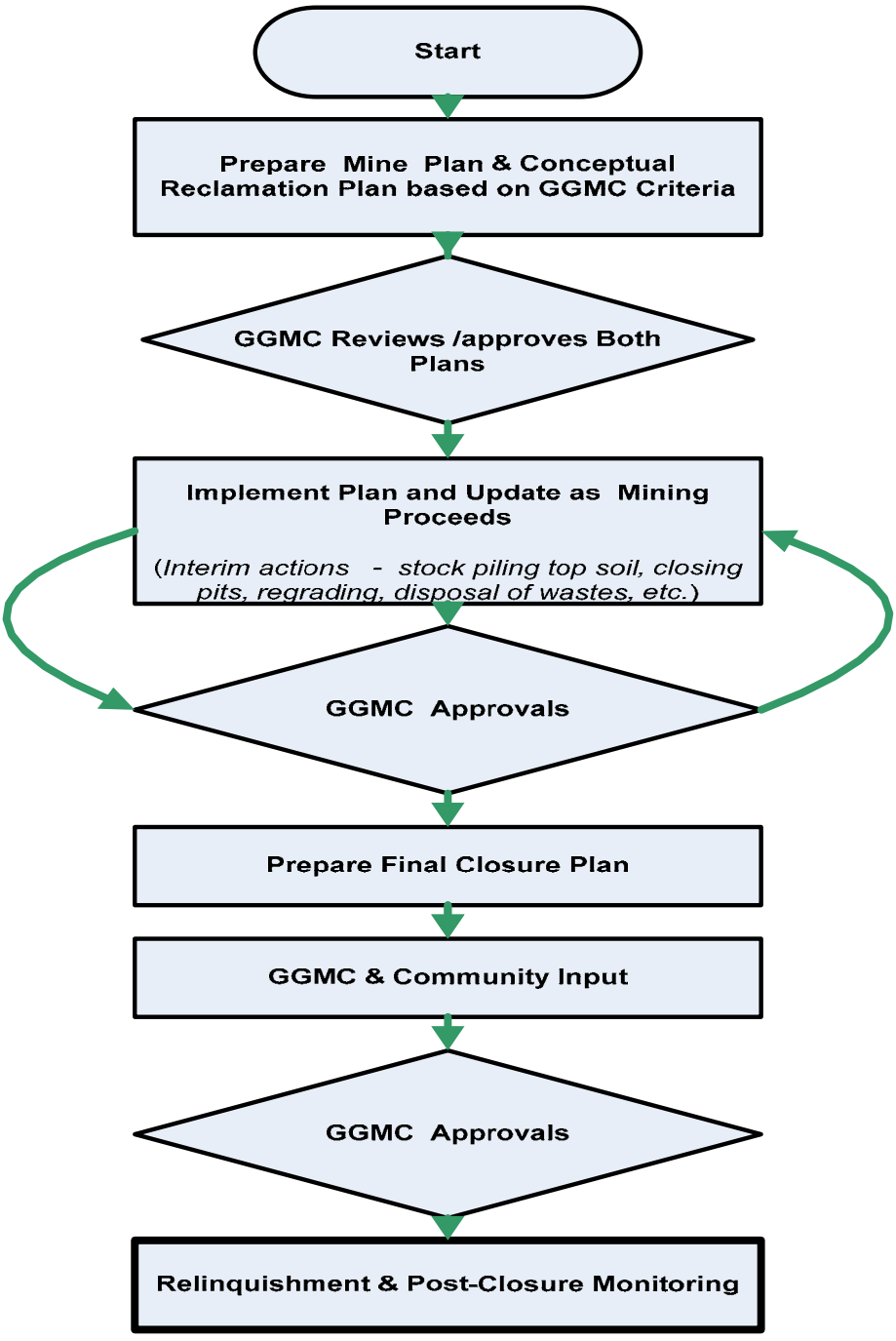

Figure 1: Basic Mine Reclamation and Closure Flow Chart

4.0 Scope

This Code of Practice (Provision) is a mandatory code that applies to gold and diamond mining operations ranging in size from small-scale to medium-scale. It addresses all issues related to mine reclamation and closure, including progressive reclamation.

This Code is subordinate to the Mining (Amendment) Regulations 2005 and intended to complement regulatory requirements, not to replace them. Compliance with the rules, regulations and laws is therefore necessary.

No guarantee is made in connection with the application of the Code to prevent hazards, accidents, incidents, or injury to workers and/or members of the public at any specific site where mine reclamation is carried out.

5.0 Principles and Standards of Practice

Mine reclamation is guided by 6 basic principles that apply whatever the size of the operation:

- Planning reclamation prior to the commencement of mining;
- Rehabilitation carried out concomitantly with mining (the "close as you go" approach);
- Ensuring physical and chemical stability of the site;
- Land use (visual aspect and productivity);
- Monitoring;
- Relinquishment.

(For further details on how the following principles may be implemented, the readers should refer to ***Section 6 Code Implementation***).

5.1 Reclamation Planning

Principle: Ensure that reclamation is planned prior to the commencement of mining operations so that the process of closure occurs in an orderly, cost effective and timely manner with the allocation of adequate resources.

Standards of practice

5.1.1 The Regulatory body should set clear and unambiguous reclamation goals and objectives for small-scale and medium-scale mining taking into account applicable regulations and outcome of community consultations.

5.1.2 The Regulatory body should prepare reclamation alternatives for small-scale and medium-scale mining and assess the different reclamation alternatives' viability against a number of criteria such as: the ability to meet expected environmental conditions, cost effectiveness, available technologies and maintenance and monitoring requirements.

5.1.3 The mining license or mining permit holder should select a reclamation alternative and prepare a conceptual Reclamation Plan.

5.1.4 Create appropriate conditions for rapid revegetation after mining has ceased

5.2 Progressive Reclamation

Principle: Integrate mine decommissioning and closure with day to day management.

Standards of practice

5.2.1 The mining license or mining permit holder should prepare a more detailed Reclamation Plan as the mine develops to ensure the greatest efficiencies are achieved through progressive reclamation.

5.2.2 The mining license or mining permit holder should integrate progressive reclamation into the conceptual Reclamation Plan.

5.2.3 Plan decommissioning and reclamation throughout the life of the mining operation: "*Close as you go*".

5.2.4 The mining license or mining permit holder should update the Reclamation Plan regularly to accommodate changes as a result of factors such as: future developments; changes in industry practices and available technology; rehabilitation success as determined by monitoring, increase/decrease of expected ore reserves; land use options.

5.2.5 The mining license or mining permit holder should provide adequate securities to protect the community from closure liabilities.

5.3 Physical and Chemical Stability of the Site

For the purpose of the present Code of Practice, hazardous wastes also include hydrocarbons (fuels and lubricants).

Principle: Ensure that all materials and structures remaining on a mine site after operations have ceased are physically and chemically stable so as to eliminate unacceptable health hazards, ensure public safety and protect the environment.

Standards of practice

5.3.1 Correct any hazard to the public associated with openings to surface (shafts, raises, stopes open to the surface, adit, etc.) in underground mines.

5.3.2 Prevent and/or control safety hazards related to slope stability including impoundment structures such as tailings ponds, settlings ponds and mining pits.

5.3.3 Control erosion processes that may cause sediment release.

5.3.4 Regrade or contour land surface to blend into surroundings and facilitate drainage

5.3.5 Prevent or stabilize any surface disruption (caving, collapse of crown pillars, subsidence) that may present a hazard to the public.

5.3.6 In underground mining, prevent rib or barrier pillars instability in order to protect neighboring operations.

5.3.7 Prevent and/or correct acid mine drainage and/or leaching of contaminants.

5.3.8 Minimize visual impacts, initiate revegetation and ensure productivity of land once mining has ceased.

5.4 Land Use

Principle: Ensure that mined lands are restored to an acceptable alternate use when pre-mining conditions may not be the most desirable post-reclamation land use.

Standards of practice

5.5.1 Restore the site to a condition in which it is visually acceptable to the community and productive for further uses. Ensure that the rehabilitated land blends in with the surrounding landscape.

5.5.2 Reclaim the site to the extent that the area impacted will be amenable to support a balanced diversity of flora and fauna.

5.5.3 Prevent drainage interruption and groundwater loss.

5.6 Pre and Post-Closure Monitoring

Principle: Verify that reclamation goals, targets and objectives are being met during progressive reclamation and after decommissioning through an appropriate monitoring program.

Standards of practice

5.6.1 The landowner is responsible for the development of a pre and post-closure monitoring program that will address physical and chemical stability of all materials and structures on the mine site as well as environmental impacts and biological response.

5.6.2 Regulatory approval is required before implementation of the monitoring program

5.6.3 Implement the monitoring program as mining progresses and as progressive reclamation actions are performed (Landowner).

5.6.4 Verify performances against goals and targets (Regulatory body)

5.6.5 Update Reclamation Plan accordingly (Landowner).

5.7 Relinquishment

Principle: Relinquish mine title once all agreed standards and completion criteria for decommissioning and reclamation have been achieved and the site is no longer a danger to public health and safety, is not a source of ongoing pollution or instability and allows a productive use of the land similar to its original use or an acceptable alternative.

Standards of practice

5.7.1 The Regulatory body should define a set of generic standards and completion criteria for decommissioning and reclamation.

5.7.2 A responsible authority/multi-stakeholder committee to be held accountable for making the final decision (Identified by the Regulatory body).

5.7.3 Relinquish the mining title once all agreed standards and completion criteria for decommissioning and reclamation have been achieved.

5.7.4 The Regulatory body should maintain a repository of reclaimed properties to maintain records of the closed sites to facilitate future land use planning.

6.0 Code Implementation

6.1 Reclamation Planning

Content of the reclamation Plan

6.1.1 The contents of the Reclamation Plan should include all or most of the following:

- Schedule
- Site Security and Safety
- Location and access
- The backfilling of mine pits, where applicable
- The sealing or capping of shafts at closed mines
- Storage and stockpiling topsoil
- Revegetation of disturbed lands
- Soil amelioration
- Restoration of watercourses, where appropriate, and drainage control
- Mine workings
- Mine development Rock, Overburden and Topsoil Piles
- Tailings Impoundment
- Water Management and Treatment
- Buildings, Equipment and Infrastructure
- Landfill Waste Disposal
- Chemical and Fuel Storage Areas
- Hazardous Waste Storage and Disposal
- Monitoring Plan

6.1.2 Mine closure should not be an “end of mine life process” but should be integral to “whole- of-mine life” if it is to be successful.

6.1.3 A schedule should be provided to describe the implementation of progressive reclamation. Such a schedule should also be provided for each stage of reclamation during the shut-down and decommissioning procedure.

6.1.4 If necessary, estimating costs for decommissioning at the early stages of mine planning can be achieved using unit costs (per ha, per m, per ton, etc.) for similar work done elsewhere.

6.2 Progressive Reclamation

6.2.1 Runoff collection and dispersion as well as sediment collection structures should be implemented in order to prevent suspended material from being charged into water streams.

6.2.2 Keep the topsoil biologically active for further use in revegetation the site. This can be achieved by moving the soil to allow the introduction of oxygen or by seeding.

6.2.3 Ensure that erosion by wind and water is minimized during and following operations and reclamation.

6.2.4 Re-vegetate the area throughout mine life with appropriate plant species that will control erosion, provide diversity and enable plant succession so as to restore a stable and compatible ecosystem. The sooner re-vegetation is initiated, the faster an ecosystem will be re-established.

6.2.5 Where possible, re-spread cleared vegetation on disturbed areas.

6.3 Physical and Chemical Stability of the Site

Rehabilitation measures are summarized in Tables 6-1, 6-2, 6-3, 6-4 and 6-5, taken from *Mine Rehabilitation for Environment and Health Protection - a trainer's manual (UNEP/WHO, 1998).* Soils Stabilization and Seeding and Revegetation techniques are provided in Appendix A and B.

Table 6-1
Reclamation Measures- Surface Workings
(Modified after UNEP/WHO 1999)

Issue	Reclamation Objectives	Control Technologies
PHYSICAL STABILITY ISSUES		
• Safety • Hazardous cliffs • Water hazard • Failing and hazardous slopes	• Restrict access to hazardous areas • Emergency access to drinkable water in case of groundwater disruption	• Ditch and berm • Fence, & sign post, if necessary • Slope stabilization where practicable • Provide emergency access to water
• Slope Failure • Deep seated or overall slope failure • Erosion	• Prevent deep seated failure, if practicable • Restrict access to unstable areas • Control sediment release, if necessary	• For potentially unstable slopes, either stabilize by flattening slopes or constructing toe berm, or restrict access with ditch/berm &, if necessary, fence & sign post • Provide stable spillway & overflow channel, rehabilitate for fish, waterfowl, and wildlife habitat.
CHEMICAL STABILITY ISSUES		
• Acid drainage and/or leaching of metals • Turbidity	Meet water quality objectives by; 1. Control reactions 2. Control migration 3. Collect and treat 4. Settlement	• Flood to control reaction • Cover to control reactions and/or migration • Collect and treat, active treatment to be avoided where possible • Settlement to control turbidity
LAND USE ISSUES		
•Productivity of land •Visual impacts •Visual impact of river	Return to approved alternative use	• Backfill pit where practicable & beneficial • Flatten slopes • Contour - blend with natural topography

•Gold and diamond mining tailings piles		• Establish vegetation • Return tailings to riverbed

Table 6-2
Reclamation Measures- Mine Rock and Overburden Piles
(Modified after UNEP/WHO 1999)

Issue	Reclamation Objectives	Control Technologies
PHYSICAL STABILITY ISSUES		
• Slope failure • deep seated or overall slope failure • erosion • Drainage disruption	• Avoid deep seated failure • Avoid large surface slumps and • sediment release • Avoid blockage of drainage	• Site selection to avoid low strength foundations (P) • Internal drains to prevent water table rise • Construct in lifts to achieve flatter slopes • Covers to control infiltration of water • Ditches for water management • Bulldoze crest, if required, to flatten slope • Construct toe berm to stabilize slope and to flatten inclination • Collect sediment in ponds • Establish vegetation or riprap, where required • Monitor
CHEMICAL STABILITY ISSUES		
• Acid drainage and/or leaching of metals or contaminants • Turbidity	Meet water quality objectives by: 1. Control reactions 2. Control migration 3. Collect and treat 4. Settlement	• Underwater disposal to control reactions • Pre-treatment-blending of alkaline material to mitigate acid drainage (P) • Cover to control reactions and/or migration and/or turbidity • Settle to control turbidity • Segregation of deleterious materials for controlled disposal or cellular pile construction • Collect and treat, active treatment to be avoided where possible Monitor • Complete detoxification of all cyanide dumps, as required
CHEMICAL STABILITY FOR SPENT ORE PILES		
•Flushing of mill reagents •cyanide	Meet water quality objectives by: 1) Control reactions 2) Control migration	• Detoxify by flushing with water or other solution to degrade cyanide to pH<7 • Regulate seepage to meet water quality objectives with covers and/or retention pond

	3) Collect and treat	prior to release
• Flushing of acid		• Detoxify by flushing with lime solution to achieve effluent water quality which meets mine effluent objectives, if possible • Regulate seepage to meet water quality objectives with cover • Collect and treat - active treatment to be avoided where possible
LAND USE ISSUES		
• Productivity of land • Visual impacts	• Returned to acceptable alternative use	• Contour-blend with natural topography • Establish vegetation where practical

(P) - Option to be implemented at approved pre-mine stage.

Table 6-3
Reclamation Measures- Tailings Impoundment
(Modified after UNEP/WHO 1999)

Issue	Reclamation Objectives	Control Technologies
PHYSICAL STABILITY ISSUES		
Tailings • Dust • water erosion	Control dust migration Control tailings erosion	• Establish erosion resistant covers of vegetation soil, riprap or water • Monitor
Dams • Deep seated or overall slope failure • surface slump • erosion	• Factor of safety >1.5 for static • conditions • Erosion resistant overtopping • protection • Restrict access	• Appropriate site selection and dam design (P) • Where necessary, stabilize embankments by constructing toe berm to flatten overall slope • Riprap or vegetation cover to control erosion • Increase freeboard and/or upgrade spillway to prevent overtopping • Ditch/berm/fence to prevent erosion by motorized vehicles • Monitor Internal + toe drains
• Weathering • Destruction of permanent structures, spillways, decant towers &	• Remove or establish long-term stability • Integrate with local drainage	• Remove or plug/backfill structures • Diversions and spillways designed for long-term stability • Plug/seal decant lines through embankments

pipes • Drainage disruption		• Define and provide for long-term monitoring and maintenance • Avoid ongoing operation where possible
CHEMICAL STABILITY FOR SPENT ORE PILES		
• Tailings and pore water • acid drainage • leaching • mill reagents (including mercury) • Water quality	Meet water quality objectives by: 1) Control reactions 2) Control migration 3) Collect and treat	• Implement permanent control measures • Flood to control reactions • Pre-treatment-removal of deleterious material form controlled disposal elsewhere or blending with alkali material to mitigate acid drainage (P) • Cover to control acid reactions and/or migration using inert material or bog (biological filter) • Ditch to divert runoff • Collect and treat - active treatment to be avoided where possible (requires continued maintenance)
Dams, structures	Meet water quality objectives by: 1. Control reactions 2. Control migration 3. Collect and treat	▪ materials which are Do not construct with potential acid producers or are leachable ▪ Decontaminate and/or remove acid generating or leaching materials
LAND USE ISSUES		
Productivity of land • Visual impacts	Return to acceptable land use	Rehabilitate by one or more of the following means: flood, contour, cover, establish vegetation, wetland

(P) - Option to be implemented at approved pre-mine stage.

Table 6-4
Reclamation Measures- Water Management
(Modified after UNEP/WHO 1999)

Issue	Reclamation Objectives	Control Technologies
PHYSICAL STABILITY ISSUES		
Water dams - stability - erosion	• Control dust migration • Control tailings • Ensure long-term stability	• Maintain embankment indefinitely • Breach dam • Maintain operating spillway in durable Rock

Issue	Reclamation Objectives	Control Technologies
- overtopping - intakes/ decant towers	• Protect erodible slopes • Ensure no overtopping • Seal pipes on dams	• Plug intakes with concrete, plug decants and remove towers • Monitor
Ditches - Overtopping - erosion	• Adequate flood capacity • Prevent blockage • Prevent erosion	• Design for extreme events • Construct from materials suitable for long-term stability • Riprap protection • Provide for long-term maintenance • Monitor
Storage Tanks • Stability	• Remove	• Drain, remove or knock down, fill, & cover • Monitor
Pipelines • Collapse • Obstruction	• Remove surface and large shallow pipes	• Remove all surface and large shallow pipe • Plug those pipes at depth • Monitor
Culverts • Blockage • Collapse	Ensure maintenance free passage of water under design flood conditions	• Remove and breach if not require • Upgrade to pass design flood • Provide for long-term maintenance • Monitor
CHEMICAL STABILITY FOR SPENT ORE PILES		
Contaminated Reservoirs	Meet water quality objectives by: • Control reactions • Control migration • Collect and treat	• Drain, treat and discharge • Strip and dispose of contaminated soils in tailings dam or approved location • Breach dam • Establish vegetation • Treat indefinitely, if necessary • Monitor

Issue	Reclamation Objectives	Control Technologies
LAND USE ISSUES		
Dams - Interruption of drainage	• Restore drainage patterns • Determine if alternative use exists	• Breach and restore to erosion resistant drainage • Stabilize to maintain dam
• Reservoirs • Productivity of land • Potential water supply	Return to acceptable alternative use	• Maintain dam • Drain and establish vegetation
Ditches	Restore drainage patterns	• Grade to restore natural drainage • Establish vegetation

Table 6-5

Reclamation Measure – Buildings and Equipment

(Modified after UNEP/WHO 1999)

Issue	Reclamation Objectives	Control Technologies
PHYSICAL STABILITY ISSUES		
• Safety and access • Maintenance and stability - Building - hoist & shaft facility - power plant - conveyors - mobile equipment	Control access	• Decontaminate if necessary • Disassemble & remove all • equipment and buildings • Backfill excavations • Remove buried tanks • Restore natural drainage
CHEMICAL STABILITY FOR SPENT ORE PILES		
• Buildings - insulation • Chemical storage	• Make secure • Monitor stored supplies	Chemicals of all types to be recycled, returned to vendor, sold or disposed of in an approved site

areas • Mill reagents • Petroleum products • PCBs • Explosives	• Meet water quality criteria • Dispose of surplus chemicals • off-site	
LAND USE ISSUES		
• Alternative uses • Productivity • Visual	Original or acceptable alternative use	• Contour • Vegetate • Break and bury concrete • Restore natural drainage

Table 6-6

Reclamation Measures- Underground Workings

(Modified after UNEP/WHO 1999)

Issue	Reclamation Objectives	Control Technologies
PHYSICAL STABILITY ISSUES		
Openings to surface which are hazardous to public (shafts, raises & stopes open to the surface, and portals to adits & declines)	• Prevent inadvertent access • Permanently seal openings	• Minimize number of openings (P) • Permanently plug or seal all access openings to surface • Backfill shafts & stopes, if practical • Fence areas • Place warning signs around
Surface disruption which are hazardous to public (caving, collapse of crown pillars	• Prevent inadvertent access • Surface stabilization • Underground stabilization	• Use mining method resulting in stable surface (P) • Stabilize surface, if feasible • Ditch/berm &, if necessary, fence & sign post unsafe areas until natural stabilization occurs • Backfill surface openings, if practical
Surface disturbance (subsidence)	• Surface re-contouring where beneficial	• Use mining method resulting in stable surface (P) • Re-contouring or diversion to establish drainage patterns
Barrier pillars stability which are hazardous to neighbouring operations	• Prevent collapse and flooding of adjacent mine • Prevent collapse and stress transfer to adjacent mine	• Permanently support boundary pillar, if practical and necessary • Ensure access to neighbouring mine and continued pumping, if required
CHEMICAL STABILITY ISSUES		
• Acid drainage and/or leaching of minerals or contaminants • Seepage of mill reagents from backfill	Meet water quality objectives by: 1. Control reactions 2. Control migration 3. Collect and treat	• Flood workings to control reactions • Permanently plug workings & drill-holes to control migration • Collect & treat passively; active treatment to be avoided where possible • Drain all oil containing equipment, motors, transformers, etc.

LAND USE ISSUES		
Productivity & aesthetics - Drainage disrupted - Groundwater lost	• Return to original or accepted alternative use • Establish surface and groundwater drainage patterns	• Backfill disrupted portions & openings where practicable • Contour surface • Flood workings • Establish vegetation

6.4 Land-Use

See Tables 6-1 to 6-6 above for Reclamation measures regarding land use.

6.5 Monitoring

6.5.1 Physical and Chemical Stability Monitoring

A sound monitoring program should detail:

- Its objective;
- Contact information of the persons responsible for monitoring
- Location of control stations
- Inspection frequency
- Type of monitoring (visual inspections, measurements, parameters, etc.)
- Instrumentation used
- Data compilation and evaluation of information gathered.

6.5.2 Environmental Monitoring

An environmental monitoring program should detail:

- Its objective
- Contact information of the persons responsible for monitoring and the laboratory responsible for analysis
- Location of control stations (on-site, upstream and downstream of the receiving environment, groundwater, etc.)
- Parameters (physical, chemical and biological), and sample media (water, soil, air, organic, etc.)
- A description of the sampling tools and measurement systems used (pH, flows, etc);
- Sampling methods and frequency
- Description of analytical techniques and their accuracy including instruments used;
- Method used to compile and assess data.

In case of having an effluent treatment facility to be maintained on site, a specific monitoring program should be designed and implemented for the facility.

6.6 Relinquishment

6.6.1 Relinquishment of a mining title may be a staged process as progressive completion criteria and targets are achieved.

6.6.2 A sufficient period of time should have elapsed to demonstrate the stability of the site. For re-vegetated areas, this may require that the vegetation has reached, or is trending towards, a self-sustaining status. Potential impacts on groundwater may also take several years of monitoring to establish or refute.

6.6.3 The responsible authority designated by the Regulatory body will make a judgment on the achievement of the agreed completion criteria after consultation with other involved regulatory agencies, including the future land manager.

7.0 Monitoring and Surveillance

There is no specific monitoring associated with the implementation of this Code of Practice. The property owner will coordinate the development and implementation of the Mine Reclamation and Closure Plan with GGMC Mines and Environmental Officers.

8.0 Emergency Measures

There are no additional emergency measures or considerations related to the implementation of this code of practice

9.0 References

Australia Environment Protection Agency (2002), *Mine Decommissioning.* Best Practice Environmental Management in Mining, 2002, 39 p.

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Government of Guyana (2002), *Regulations made under the Mining Act (No. 20 of 1989) proposed amendments.*

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Quebec Ministry of natural Resources (1997), *Guidelines for preparing a mining site rehabilitation plan and general mining site rehabilitation requirement* Quebec Ministry of natural resources, 1997, 61 p.

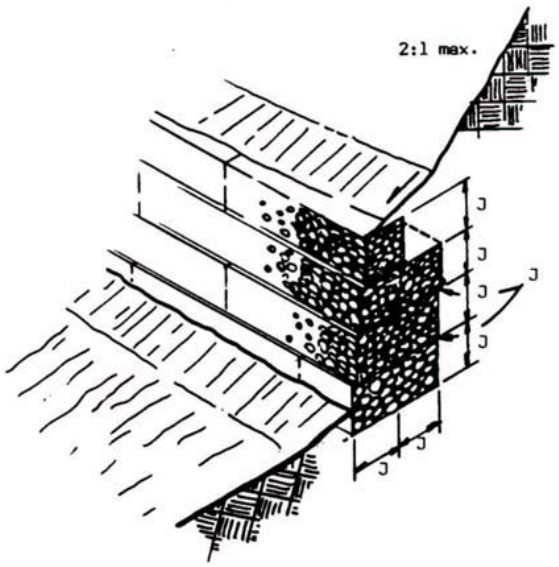
Ripley, E.A., Redman, R.E. and Crowder, A. (1996), *Environmental Effects of Mining.* St. Lucie Press, 1996, 356 p. Lucie Press, 1996, 356 p.

UNEP and WHO (1998), *Mine Rehabilitation for Environment and Health Protection - a trainers manual* (UNEP/WHO, 1998), 430 p., stock no. PM38.

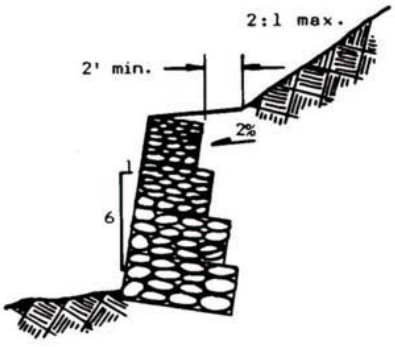
Web site
http://xmlwords.infomine.com/xmlwords.htm (on-line dictionary of mining terms)

Appendix A: Permanent Soil Stabilization Techniques

Gabions



3-DIMENSIONAL



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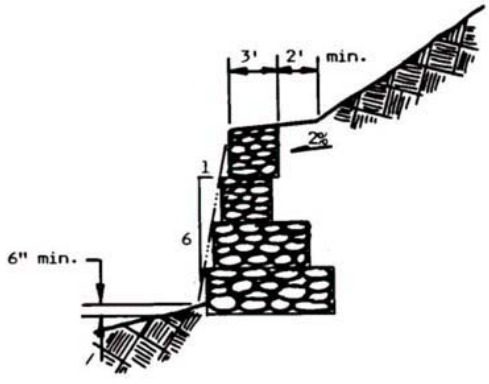
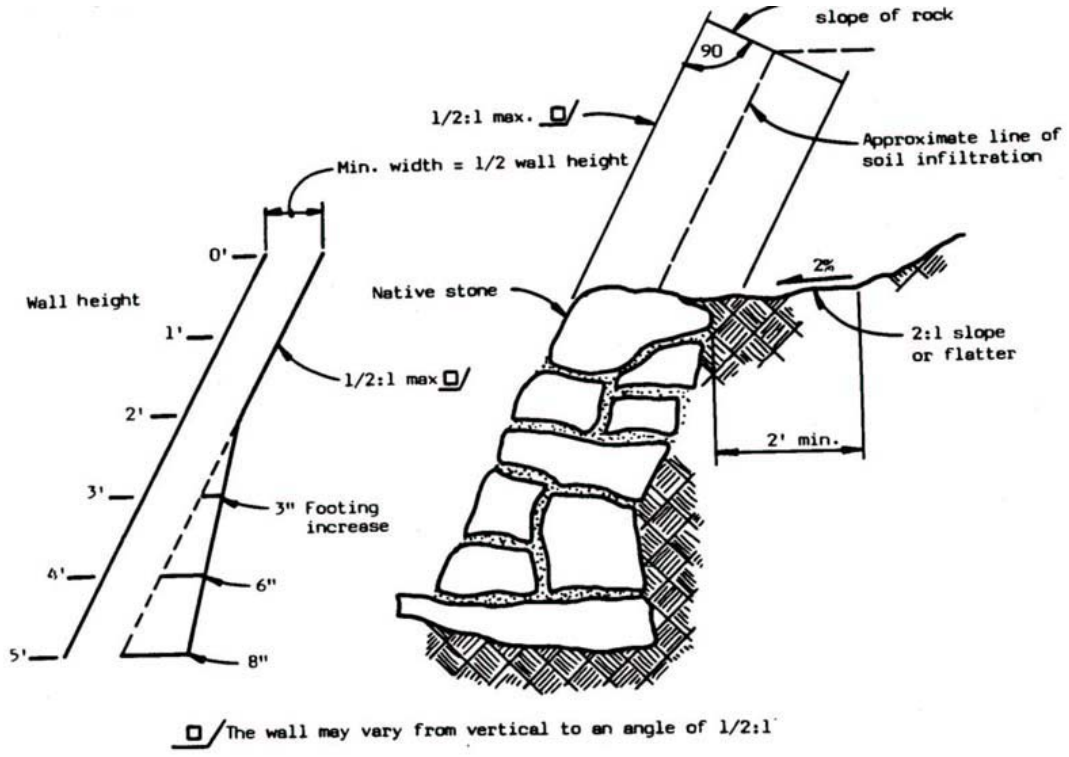


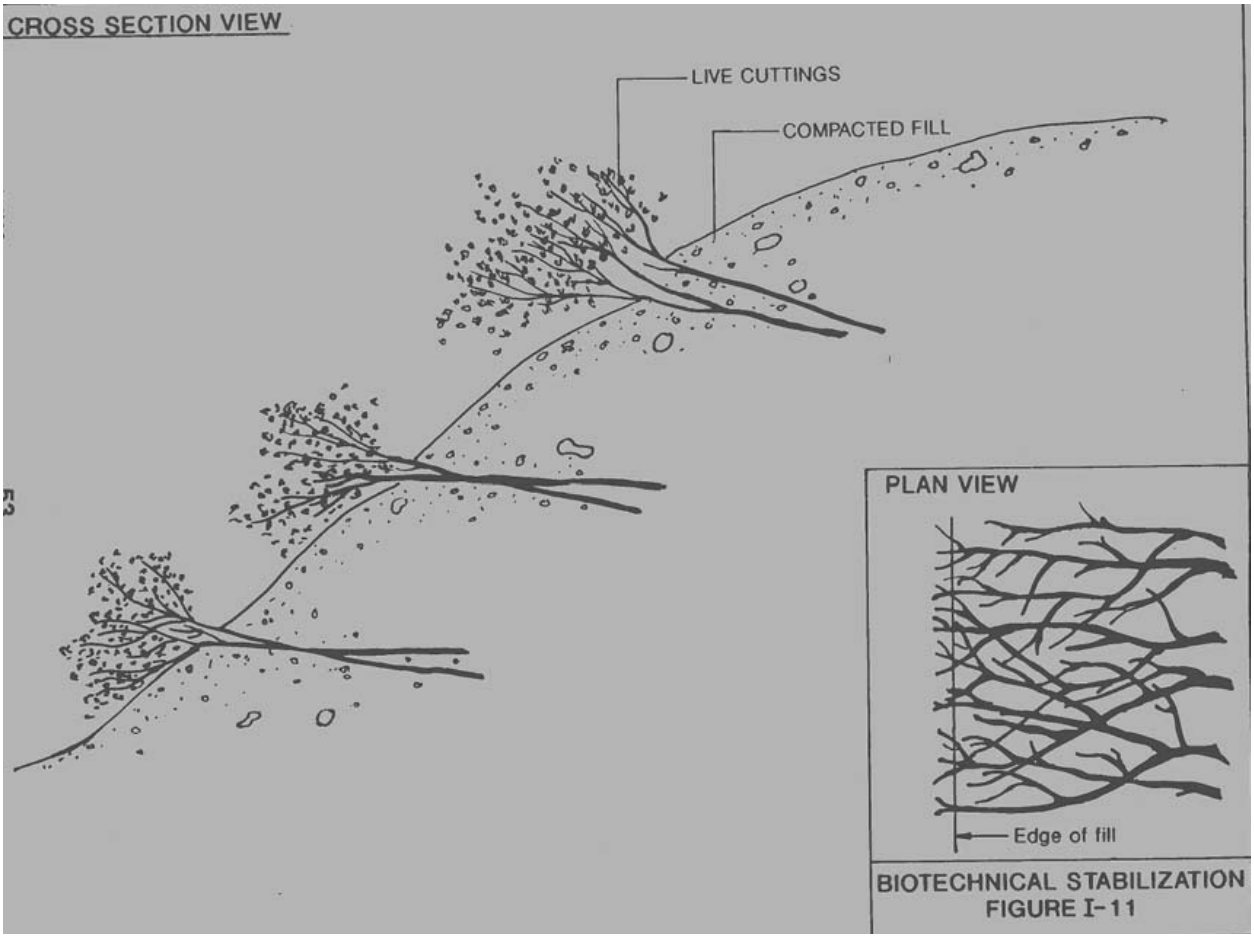
SECTION

Native Rock Retaining Wall



Biotechnical Stabilization

(Five layers of brush imbedded in the ground)



Woody plant (dormant) materials are placed into soil at select locations to provide stability to the slope. The degree of stability and drainage increases as the branches take root and grow.

Appendix B: Seeding and Revegetation Techniques

Topsoiling

Topsoiling is the placement of topsoil or other suitable plant growth material over a prepared-topsoil.

Purpose: To provide a suitable soil medium for vegetative growth.

Seedbed Preparation

Seedbed preparation entails preparing the soil by ripping, discing, scarifying, and adding soil amendments to make the soil more productive and enhance revegetation efforts.

Purpose: To promote successful revegetation efforts by preparing the soil for planting and creating propped seedbed conditions.

Broadcast Seeding

Broadcast seeding is the process of uniformly casting seeds and fertilizer on the soil by hand or mechanical means.

Purpose: Broadcast seeding is employed when seeding grasses, shrubs, forbs, or trees on flat surfaces and slopes where other seeding methods are not appropriate. Broadcast seeding is well suited for use on steep slopes, rocky areas, abandoned roadways, sites with limited access, and where hand labor is used.

Drill Seeding

Drill seeding is the process of planting seed and fertilizer using an agricultural or rangeland drill seeder.

Purpose: This method is most effective on flat, non-rocky surfaces. Drill seeding provides the maximum possibility for successful germination and growth, with a minimum investment in fertilizer, seed, and labor because seeds are not damaged or carried away by wind, water, animals, or birds.

Vegetative Planting

Vegetative planting means the establishment of vegetation by planting trees and shrubs from nursery stock and transplants.

Purpose: Planting vegetation is an effective means of promoting soil stability and controlling erosion; however, until establishment is complete the site is vulnerable to erosion. Trees and

shrubs should be planted in conjunction with grasses and legumes to enhance the overall effectiveness of soil stabilization efforts and erosion control measures.